Utilizing Different Aquatic Resources for Livelihoods in Asia

General Issues and Principles

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The Role of Small-Scale Aquaculture in Rural Development

Poverty alleviation is central to the concept of rural development. However, the prevailing development strategy in the 1960s and 1970s of structural change based on urban-industrial growth did not lead to the trickle-down of benefits to poor people in rural areas. “Rural development” approaches, thus, emerged to address more directly the problem of rural poverty.

Different approaches to rural development

- Basic minimum needs provision, implying a continuation of paternalistic attitudes by government
- Integrated rural development, emphasizing the need to address both the economic and social issues
- Employment creation, emphasizing the economic sector

Key principles emerging

- Peoples’ participation
- Bottom-up planning

This has been just as true of aquaculture as with other sectors. After concentrating on intensive systems based on high-external input
technologies in the last decade, significant attention has begun to be paid to rural aquaculture, a portfolio of technologies which are specifically oriented to address the needs of the poor people.

Poverty, however, is complex and poor rural people do not rely for their livelihood on the agricultural sector alone. This perception has led in recent years to the emergence of “sustainable rural livelihoods” as an approach for the analysis of poverty and possible intervention for its alleviation. This approach examines the position of rural households in relation to the availability of various capital assets.

**Assets**

- **Natural capital:** access to land, water, forests and other resources
- **Physical capital:** presence of roads, irrigation systems, schools and other important economic and social infrastructure
- **Human capital:** available labor and skills, experience and education of the rural household
- **Financial capital:** investment resources available to the household, whether from their own savings or the presence of credit systems
- **Social capital:** namely the networks which may be tapped to support the individual household. Support may come from informal associations within the village community or from formal institutions at local, sub-regional and even national level.
Factors affecting the basic assets

Vulnerability forces

These forces may include sudden shocks in the physical environment such as drought, flood or typhoons, or longer term trends in the economic environment and resource stocks. Both of these can reduce the assets normally available to the household.

Transforming structures and processes

Transforming structure and processes refers to the nature and operation of the institutional environment, encompassing public and private institutions, laws, policies which can work positively or negatively to affect access to capital and maintenance of it (Carney, 1999). It is in response to their asset situation, in the context of the various vulnerability factors and the prevailing structure and processes, that the rural poor develop their livelihood strategies.

The challenge for aquaculture is whether it can help strengthen the assets available to rural households so that they are better able to
withstand shocks, become less vulnerable and are better able to influence the policy/institutional environment in their favor. We now examine whether aquaculture is able to do this.

**Potential roles and impacts of aquaculture on poverty and rural livelihoods**

Aquaculture may assist poor rural households by enhancing their natural capital stocks. In relation to natural capital, rural people may be poor because:

I they lack such capital assets (for example land, in the case of the landless);

I the scale and quality of their natural capital (the context of small-scale farmers in resource-poor environments) are limited; and

I the natural capital on which they depend has been degraded (for example in the case of fishers previously dependent on catches from either the freshwater or the marine environment).

By creating, adding value to or restoring natural capital, aquaculture may contribute to the livelihoods of poor households directly involved in the enterprise. The underlying benefits of direct involvement would be improved food security, creation of employment opportunities and income generation. In addition, aquaculture may improve the sustainability of other farm enterprises.

For those with land, where pond aquaculture is practiced

The pond offers an extra source of water to help offset the effects of drought on staple crops and provide water for vegetables and fruit. This is particularly the case in areas of resource-poor agriculture, which is dependent on erratic rainfall.

Where aquaculture is practiced in paddy fields

The incorporation of fish in the system can both improve rice yields and reduce costs of production.

**For the landless**

Common property resources may provide an opportunity for aquaculture provided that villagers have the social capital to secure
access to the resources and eventually enhance them. In these cases, aquaculture becomes an entry point for building up other assets.

For fishers

Aquaculture may help to replace the livelihood lost through overfishing or environmental destruction. In order to ensure a sustainable operation, the need for major investment in physical capital is recognized.

**Indirect benefits from aquaculture**

- Reducing the cost of fish to rural consumers
- Creating wage employment on larger farms or in fish products processing
- Cheap fish for urban consumers

**Barriers to entry of aquaculture**

The high investment required in the creation of physical capital for aquaculture such as pond, trench or cage, the excavation, etc., might not seem affordable. Additionally, the costs of fish seed, feed and/or fertilizers and harvesting equipment have to be considered.

In fact, the investment costs are rarely as high as might be assumed, especially in traditional rice-fish societies, so that access to aquaculture is well within the existing financial and social capital stocks of the farmer.

In order to provide human settlement in low-lying lands in flood plains,
ponds are excavated in order to use the soil as a platform for the homestead to raise it above the flood.

This automatically gives the household at least a small pond close to the house. Aquaculture frequently develops as the pressure on the existing rice-field fishery increases. To attract wild fish to their particular part of the paddy, farmers dig small pits or ponds which act as sumps as the water recedes trapping the fish. These “trap ponds” may be widened and deepened as the farmer becomes more oriented to aquaculture.

While these traditional practices form a low-cost basis for the development of aquaculture, so do development projects. Construction activities usually require excavation of soil for landfill elsewhere and farmers may find themselves being given an opportunity for free pond excavation as a result. Evidence from Bangladesh demonstrates that even burrow pits and on-farm ditches can be a resource for the landless, especially with the introduction of tilapia culture which offers the opportunity of sale of swim-up fry after just a few months.

In traditional rice-fish culture in upland areas in the Lao PDR and Vietnam, these ponds may be used to stock broodfish throughout the winter season, allowing farmers to produce their own seed locally and to reduce dependence on more expensive, imported supplies.
At present, development projects recognize that the farm pond is a key element in the creation of physical/natural capital for poor households, thus, offering free or subsidized services for pond construction. Whether this is seen as a fish pond or not, fish culture usually adds value to the resource unless it is also to be used for drinking water supply (as was the constraint in the Family Food Production Project, an early attempt to promote aquaculture in Cambodia).

These issues only relate to land-based systems. For the rural poor, often landless, open access or common property aquatic resources may offer access to aquaculture:

**Freshwater context**

Resources may include backswamps and oxbows in flood plain environments or small reservoirs, including watershed catchments in small tributary valleys.

**Coastal areas**

Where many coastal fishers have been suffering from reduced catches in recent years, sheltered estuaries and bays constitute potential resources. The big issue in these cases is whether the rural poor can secure permanent access to the use of the water bodies concerned, i.e., whether existing power structures and processes in the community facilitate this access.

Another constraint to coastal aquaculture is the openness of the area. With open access to coastal areas, individuals have difficulty obtaining tenure and even communities may not have jurisdiction. Even when they do have jurisdiction, their ability to enforce control is constrained by the physical openness of the sea.

**Technical options for small-scale aquaculture**
Many opportunities await the rural poor people when they take part in this enterprise without major capital investment. The issue centers on availability of suitable technology for fish culture and if this technology is accessible to poor people. Aquaculture technology is perceived to be either physically inaccessible or too risky for many rural poor people. However, these were based on conventional approaches that are now being superseded.

Two main stages in aquaculture production

1. Seed production
Supply of quality seed is fundamental to developing the enterprise. Apparently, many areas are characterized by inadequate seed supply despite the widespread development of large-scale hatcheries, often with donor funding. However, hatchery facilities have been decentralized and small farmers in rural areas can even produce their own seed without conventional hatcheries.

For many estuarine and marine species, natural sources of seed with acceptable reliability are abundant. Wild seed is currently the only acceptable economic option for oysters, mussels and clams. For other marine species, there is sufficient wild seed for small-scale production, although this begins to be an issue as the area of culture expands.

Farmers in the highland valleys of Vietnam and the Lao PDR have traditionally spawned fish (e.g., common carp in paddy fields). Such systems remain common in more developed areas in Indonesia and China. Small carps and tilapias can be bred locally in pond culture, which not only reduces costs and improves quality – since long-distance transportation is no longer needed – but also provides employment and income for small-scale farmers. Those with slightly better water resources are able to breed fish, while others can nurse fish in cheap nylon cages for onward sale. Such systems have been developed in Bangladesh, Cambodia and the Lao PDR where they have had a powerful multiplier effect (Edwards, 2000 and RDC, 2000).

2. Grow-out stage
Aquaculture may be practiced in a wide variety of options. The
technologies, which offer valuable livelihood options to the rural poor, are available. These center around herbivorous and omnivorous species, which can thrive on various on-farm fertilizers and feeds and inputs that can be gathered from the wider resource system. Several systems of fish culture are based gathered grasses and other vegetation.

Other systems depend on fertilization strategies using animal manures. Some cultural constraints exist in the use of manures as well as limitations in the nature of the agricultural system, particularly where livestock are not penned. However, the culture of some improved species of Nile tilapia by the rural poor, with only limited applications of inorganic fertilizer, also has been successful.

In northern Vietnam, aquaculture systems have centered on grass carp for the last 40 years since its introduction from China. This species is reared in both ponds and cages, fed with grasses, maize residues and cassava leaves. In the south of Vietnam, an equivalent “poor person’s system” based on giant gourami, which also feeds on vegetable matter (although growth rate is a constraint), exists.

In southern Vietnam, the culture of pangasius catfish (Pangasius hypophthalmus), reared in overhung latrine ponds, is a second low-cost system. These grow quickly without purchased inputs and can be the basis of a more diversified system.

Coastal aquaculture

More work has been done in freshwater aquaculture than in coastal aquaculture in developing production systems suitable for poor people. The culture of mollusks and seaweeds appears to have high potential, while requiring only minimal investment. These water-based systems do require some investment in order to develop aquaculture but, at least initially, cages and poles for shellfish culture can be made from relatively cheap and locally available materials like bamboo.

Most coastal aquaculture technology, however, has been aimed at moderately high to high-value species. These species are too expensive for household consumption of the poor people and low-cost culture systems for these species are rare. The culture of high-value species...
entails more investment for crop security, either for physical confinement or protection from theft. Aside from the financial constraint, it is questionable whether poor people would undertake such risk-prone activities.

Conclusion

Aquaculture is more accessible to poor rural people than has been generally realized and a range of technological options now exists. However, much remains to be done.

- It is important that efforts in research and development continue to be focused upon the sorts of technical options that were described, particularly in coastal areas.

- National governments must be committed to providing an environment which allows poor people access to productive assets and resources, possibly through specifically targeted support packages.

- Strategies will often require major changes in policy and in attitude among government departments and individuals.

- Finally, bearing in mind the sustainable rural livelihood approach, the participation of the rural poor in aquaculture will depend on a whole range of social and economic factors at the farm, community and regional/national levels. In a more general context, these factors may include the key economic issue of relative “catch per unit effort” to be obtained. In the narrow sense, this involves assessment of the merits of aquaculture compared to capture fisheries and assessment of other alternative livelihood opportunities, both on and off farm.
References


Regional Development Committee (RDC). 2000. The Nursing Network. Poster submitted to the DFID Aquatic Resources Management Programme E-mail Conference on Aquatic Resources Management for Sustainable Livelihoods of Poor People.

The role of aquatic resources in poor peoples' livelihoods is complex and context specific. Aquatic resources management in the context of poverty is not limited to technology or forms of aquaculture but could include improved access to natural stocks of fish and other aquatic organisms. Policies, institutions and processes that support livelihood strategies involving aquatic resources are also important. In the past, there has been a failure to recognize the contribution of aquatic resources management to food security for the rural poor. The livelihoods of the poor, in fact, can be adversely affected by policies and practices in other sectors (especially agriculture and water management) that undervalue aquatic resources. For example, some forms of irrigated agriculture (weir and dam schemes) have had negative impacts.

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<th>Aquatic resource diversity</th>
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<td>Temperate/Tropical</td>
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Livelihoods based on aquatic resources are characterized by diversity of resources, environments, resource users and the ways people exploit resources and incorporate them into their livelihoods.

It is difficult to assess aquatic resource use by poor people. The complexity of seasonally and spatially variable environments and stakeholder activities often results in incorrect resource use estimates. Good case-study evidence may provide more valuable information. The social context is especially important, particularly access arrangements and the assessment of benefits to livelihoods.

Technical issues and lack of new knowledge are not major constraints to aquaculture development. There is a wealth of knowledge, including local knowledge, that only needs effective widespread dissemination to enhance human capital. People, not ponds or technology, are the entry point for aquaculture development. There has been a positive shift from technology-led production-oriented project interventions to a people-first sustainable livelihood approach. Poverty and environment degradation can be eliminated through holistic development interventions that facilitate diversified sustainable livelihoods.

Available statistics on aquatic resource use do not reflect reality well: they commonly under or over estimate the resource. Little information is given on seasonality and markets.

Well collected and presented information on the value of aquatic resources to poor people empowers users and their advocates. Such information is less easily ignored by competing sectors.

**Evidence of the role of aquatic resources in poor peoples’ livelihoods**
In some parts of Southeast Asia, aquatic resources constitute a large share of the animal protein intake of poor households. Households catch and consume significant quantities of fish and other aquatic products. But there is increasing evidence that wild aquatic resources are declining.

What general evidence is available on the role of aquatic resources in the livelihoods of poorer groups? For those working in the field, the role of aquatic resources in poor peoples' livelihoods is self-evident. However, policy makers need hard evidence for formulating more pro-poor policies or to make resource allocation decisions. Evidence can play a role in supporting planning and legislation and improving the institutional context of decision-making. Greater emphasis on advocacy (outside the sub-sector) is required to raise awareness of the role for aquatic resources management in rural development and to bring about desirable institutional changes.

| The role of aquatic resources in food security of poor households in Southeast Asia |
|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| NE Thailand | Cambodia | Lao PDR | Vietnam |
| **The role of aquatic resources in the diet** | **Fish and fish products account for 70-75% of the dietary protein intake of the population of Cambodia.** | Fish had traditionally contributed 85% of animal protein intake. A recent survey in Luang Prabang Province found fish to represent 50-55% of animal protein intake. Fish still represents the largest component of animal protein in the diet. | Fish in An Giang Province contributes nearly 76% of the average person's supply of animal protein. The role of aquatic resource in the diet of northern provinces is much less. |
| **Fish production/consumption estimates** | Average consumption for northeast Thailand 30-34 kg/cap/y according to three independent studies. Fish availability in the hungry season is highly valued. | Average consumption 28-41 kg/cap/y. However, eight provinces around the great lake and the Mekong (population 4.1 million out of a national population of 10.5 million) household sample surveys suggest the | Production and consumption is greater in the south than in the north. In the northern mountains, several kg/cap/y is common. In the south, e.g., Long An Province, farmers catch 531 kg/hh/y; and average fish consumption is 60 |
The consumption of fish and processed fish is at least 67 kg/cap/y. Some rice fields outside of the above provinces provide families with 62 kg/ha. Bodies contribute 66 kg/hh/y to production in Savannakhet. Average household catches in parts of Lao PDR can range from 40-108 kg (US$80-215). The average value of a rainfed rice crop is US$100. In An Giang Province, average wet rice fish catch is 835 kg/hh/y and consumption is 78 kg/capita/y; 50 kg fresh fish and 28 kg fisheries products.

| Current trends availability | In northeast Thailand there has been a steady decline in natural fish catch over the last six years in all water resources. Availability is strongly correlated with rainfall. Evidence suggests the resource in Cambodia has been underestimated. An issue for the poor is access, constrained by the sale of fishing lots and in some cases, the exclusion of local fishers and reduced quantity and size of fish migrating. Some Laotian riverine fisheries, as reported in 1984, had declined by 20%, and a 1994 report states that production in lakes and reservoirs has declined by 60% in the past 15 years. There are indications that the catches from the Red River Delta and the Mekong River System have declined considerably over the last 10-15 years. |

Technologies and processes that enhance poor peoples’ management of aquatic resources

Uncertainty in relation to the outcomes of technology use by poor aquatic resource users has been highlighted. Reference is made to the desirability of support systems that can integrate “local knowledge” and “scientific knowledge”. Participatory approaches also have an important role to play. Local knowledge commonly includes:

- time and place knowledge of resource systems;
- people who use them;
- local needs;
- desires; and
- patterns of behavior.
Processes that enhance poor peoples' management of their aquatic resources

- Incremental
- Participatory
- Adaptive
- Flexible
- Building basic husbandry and basic management skills
- Limited financial capital
- Building institutional capacity and incentive structures
- Supporting operational budget at local institutional level
- Promoting networking among sectors of small-scale producers

From fisheries, the management of ubiquitous small-scale water bodies is of particular interest. The water bodies play an important role in subsistence needs and income generation. Fisheries technologies exist to increase the standing stock and returns to fishing effort. However, initiatives to enhance the management of such systems, which catalyze changes in use patterns and access, raise important issues about managing the process, and whether benefits accrue to the poor.

Community-based co-management of fish resources can be useful in initiating more participatory approaches to the management of “nature conservation” through protected areas. In central southern Laos and Northern Cambodia, fish is the most important source of animal protein for villagers living in and around protected areas. Fisheries can be a good entry point for conducting community-based collaborative management of natural resources.

Learning and communication processes that enhance the capability of poor people to manage their resources
In the context of learning and communication, we are reminded of the plurality of knowledge that encompasses our “images of reality” and our “vision for the future”. A proper understanding of the differences in stakeholders’ knowledge is important for all those who play a role in communication and learning processes.

The traditional means of communication through extension services has tended to focus on information transfer from researchers to farmers. Perhaps one reason why aquatic resources management systems have been ignored and aquaculture systems have often favored wealthier farmers is a lack of investment in communication processes. Improving dialogue might help identify issues relevant to poorer resource-users. Organizations involved in traditional aquaculture extensions include NGOs, which work in relatively restricted areas, as well as government departments, which have a wider geographic coverage.

Developing the capacity to share information is particularly needed. It is also strongly advocated to involve support staff and aquatic resource users in developing recommendations, though top-down processes are reported to be still common place. Improving mechanisms for communication across sectors and between countries, provinces, districts and communities is important in creating awareness of good and bad management practices at various levels. A better sharing of what knowledge exists is needed, especially approaches and processes and the contexts in which they have been successful.

The weak institutional capacity of some government (and other) providers of services at local levels can limit their capacity to participate fully in learning and communication. Learning and communication processes should build on traditional systems of information storage and management already operating at local levels. Local support agencies should be assisted to be better able to record and manage the information they are expected to retain and process.

Institutions, organizations, polices and legislation that shape
People who are poor find it difficult to draw down services that could support their aquatic resources management (and more broadly their livelihood options). Promoting pro-poor approaches within policies and institutions is a particularly valuable development objective. Understanding the livelihoods of the poor is essential to the proper formulation of policies that support their objectives. Once again, participatory processes have an important role to play in uniting the poor with policy formulation processes.

From a broad range of contributions one can characterize the following key requirements.

- Expanding the structure of existing support agencies (especially local government), allowing representation of the poor and facilitating a better understanding of poor peoples' livelihoods and their participation in policy development processes.

- Assistance (catalytic) from support agencies for local organizations and networking.

- The knowledge and skills required to administer and monitor even simple technologies can become limiting factors at provincial and district levels. Seeking opportunities to build upon existing capacity, at a rate consistent with the stage of institutional development, can be valuable. Where institutional capacity and operational budgets are limited, the process is likely to be slow and long.

- The development of a long-term vision and the coordination of donor support can often be complex for local institutions to manage. Regional development structures may have a role to play in administration.

In Southeast Asia, international collaboration within and between riparian countries will probably be a major determinant of aquatic resource sustainability with important implications for poor people’s livelihoods. Stocks are shared among different parts of the region sometimes hundreds of kilometers apart because of migratory habits of most Mekong fish species. Processes leading to the formulation of policies and laws relating to the construction of hydro dams, irrigation structures and habitat conversion could benefit from information about the dynamics and value of aquatic resources.
Social and Cultural Considerations in Small-Scale Aquaculture

Aquaculture is a mode of production, which is part of a larger agriculture/fisheries/food production system. This larger system is both socio-economic and biophysical in nature. These two features are interdependent, interactive and mutually deterministic. Together, they can influence people’s decisions and their success in new technology applications and development.

The production system also involves the local community. One cannot consider development as only individual. The household context has immediate impacts on women and men as well as on the old and young. The community, political and other factors may involve different social classes, castes, or ethnic groups.

The physical connections of aquaculture through the use of water form a close link to wider ecosystems. These wider ecosystems are used and influenced not only by a range of biological and physical factors but also by people.

Aquaculture and its development should be...
**People centered.** Support should be provided only for what matters to people. The support must be sensitive to differences among groups of people and should fit their current livelihood strategies, social environment and ability to adapt.

**Conducted in partnership.** Partnership is needed in the private and the public sectors for the development of the production system, marketing, finance, regulations, technical support, training, etc.

**Multi-level.** Concerns at the micro-level, the locus of the production, must inform the development of policy (local government and other levels) for an effective and supportive enabling environment.

**Responsive and participatory.** Poor people should be key actors in identifying and addressing priorities. Outsiders will have to listen to and respond to the poor.

**Dynamic.** External support for aquaculture development must recognize the dynamic nature of people’s current livelihood strategies and be flexible to changes.

**Sustainable.** In addition to environmental sustainability, aquaculture must pass the test of social, economic and institutional sustainability.

**Small-scale aquaculture**

Aquaculture development intended as “small-scale” must be a poverty-focused development activity. As such, it should comply with the principles as adopted by DFID as core principles of sustainable livelihoods framework.

A useful framework to remember consists of the assets that people can draw upon for aquaculture development. These are:

- natural capital, e.g., water, soil, fish stocks;
• human capital, e.g., trained labor, leadership skills, artistic talents;
• produced capital, e.g., houses, roads, machines, money and financial resources;
• social capital, and e.g., relationships and trust, networks, organizations; and
• cultural capital. e.g., beliefs, shared world views, folklore.

People can use these assets to invest in aquaculture development. These are also the reserves that can be used as foundations for successful aquaculture. In other words, the benefits of aquaculture can create assets other than those reflected in the financial benefits.

Aquaculture development must be considered within the context of sustainable livelihoods and household economy. Hence, it is essential to consider family goals and aspirations.

Complementation of new technology

Complementarity of new technology is essential in aquaculture development. Aspects to be considered include the following:

• Technical complementation

New technology added to a household must complement the technologies currently being used. Conflicts will lead to rejection of new technology.

• Social complementation

Social reciprocities exist and must be considered in introducing new technology. Labor exchange is integrated with seasonality and social obligations. Access to resources may be determined by previous social conventions or arrangements.

• Economic complementation

Small-scale producers are by definition resource-poor. Financial capital will be limited and new ventures may depend on availability of limited technical and human resources. Amount and timing of economic resources are important.

• Political complementation

Access to common property or other resources may be constrained by existing political structures in a community. It is important to know who holds and uses power in the community and how their power is linked to power structures outside the community. How can the disadvantaged in the community be empowered?
Participatory methods can be used to assist communities in identifying needs and setting priorities. Simple PRA methods such as focused group discussion or problem tree analysis are examples. See guidebooks, such as, the Participatory Methods for Community-based Coastal Resources Management (IIRR, 1998).

**Participation**

People need to be involved in choices of aquaculture technology and the details of the technology. Participation in problem identification and solution will make the technology more suitable and acceptable.

People need to assess what resources are available for aquaculture development and how these might be used. They must be central in planning for collective action.

**Availability of human resources**

We cannot assume that there will be enough labor, time and skills available. In poor villages the more entrepreneurial people (more qualified and better motivated) tend to leave. Fishing and farming are often low-status occupations.

**Availability of time**

Current fishers/farmers will be very busy. Both women and men are occupied most hours of the day with current activities to maintain household welfare.

In aquaculture the benefits from investment will only be obtained much later. Investments of time and money will not return benefits of food and income until harvest. Fishers are accustomed to receiving the benefits of a day’s work on the same day. Aquaculture requires a different attitude and planning for such fishers. Farmers may be more attuned to this condition.

**Risk tolerance**

The risk factors to be considered are:

- Current lack of access to resources can make people averse to risk and less likely to take up new options.
- Options and decisions are usually based on experience. What is most meaningful is what “worked” in the past.
Familiarity supports acceptance of risk. The lack of visibility of some aquaculture stock may decrease comfort.

Guide questions for appropriate technology

A technology, to be adopted/adapted by the target beneficiaries, must be appropriate to existing conditions.

- Is it responsive to needs?
- Is it affordable?
- Is it ecologically sound?
- Is it socially acceptable?
- Are credit, training, and other support available?
- Would it require policy advocacy?
- Is it sustainable?

Ownership and management

- Community ownership or individual ownership: Will the development result in units of production being owned and operated by individuals or households? Or will it result in some form of communal enterprise? In some cultures, individual or family ownership is more successful than communal efforts. One must ensure that the development is designed to fit the potential social organization of the community.
- Access to the resources: Who controls, owns and/or manages the resources necessary for production?
- Training, credit and other support services should get to the right people. These people must first be identified. Are women involved? Are there others not visible who play an important role in the production?

Social and cultural considerations in species selection

The type of species to be used in aquaculture is critical in the investment process.

- Demand driven selection of species in aquaculture. What species are important to the potential users of aquaculture technology? Is there a market or household demand?
- Harvesting period: consider the timing with respect to religious or other festivals and holidays. Prices and availability of excess labor might be affected by
Timing.

- Peak seasons of labor demand for other means of livelihood might be in conflict with the seasonality of introduced species.

**Social and cultural consideration in technology choice**

- Availability of easily adaptable technology
- Cultural and religious acceptance of the technology
- Appropriate educational levels of users
- Technology may impact women and men differently. Consider who will be the most appropriate user of the technology.
- Consider special needs depending on the age of the expected participants.
- Children should not be involved in labor at the expense of their education.

**Social considerations regarding required resources**

- Look closely into why the resources are being used for production. Are the resources (e.g., ponds) available for use because the owner intends them for aquaculture production?

**Institutional support to the farmer**

- Social and cultural obstacles sometimes exist, particularly for government infrastructure, due to different classes of people.
- Appropriate groups should be mobilized where communal action is needed.
- Look for traditional or community-based institutions to support new development. These are likely to be more socially and culturally acceptable. But make sure they are not inclined to limit the spread of the benefits.

**Demonstration of successful technology**

- Social recognition of the best farmers creates role models in the community.
- Role models are important and need to be identified so they will have the most impact.
- Be responsive to what people need.

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The “natural” development of aquaculture is influenced by such socio-economic factors as:

- the perceived need or desire for aquaculture products;
- the suitability of available resources for supplying these products and the availability of complementary factors of production; and
- the knowledge of techniques for aquaculture possessed by the society.

Technology and technology transfer are major issues in developing the fisheries sector in Bangladesh. Towards this end, an extension methodology called trickle down system (TDS) of aquaculture extension was developed and implemented on an experimental basis during the implementation of the project “Institutional Strengthening in the Fisheries Sector in Bangladesh”. The approach was further applied on a pilot-scale with assistance from the Technical Cooperation Program of the Food and Agriculture Organization of the United Nations (FAO) to strengthen the extension services system in Bangladesh.

Continuous supervisory technological and institutional support catalyzed the farmers’ interests in aquaculture. The homestead pond aquaculture assists poor families by providing additional income as well as nutritional benefits.
However, these factors are not in themselves sufficient to ensure the development of aquaculture. A society with assured and suitable sets of property rights also appears to be necessary. Peace, law and order and good environment, when combined with the above factors, are likely to be conducive to the development of aquaculture.

The following are the possible socio-economic impacts on the household of fish farming.

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<th>Socio-economic factors</th>
<th>Possible impacts</th>
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<td>Occupational changes</td>
<td>Aquaculture generates more income than rice farming does. Because of its profitability, rural farmers and under-employed often change their profession to aquaculture.</td>
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<tr>
<td>Employment generation</td>
<td>Improved aquaculture generates full time employment for two persons per hectare and has multiple effects on allied activities.</td>
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<tr>
<td>Family Approach</td>
<td>If a family approach is used, ponds are never unattended. Women are empowered because of their role in decision-making. Children, however, should not sacrifice opportunities for attending school.</td>
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<tr>
<td>Household livestock</td>
<td>Households are encouraged to maintain livestock because of their role in fertilizing ponds.</td>
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<tr>
<td>Living standard</td>
<td>Additional income from aquaculture often translates into improved housing and sanitation.</td>
</tr>
<tr>
<td>Fund flow for fish culture</td>
<td>Aquaculture improves access to institutional credit and increases savings.</td>
</tr>
<tr>
<td>Nutrition</td>
<td>Aquaculture increases the level of fish consumption thereby improving family nutrition.</td>
</tr>
<tr>
<td>Changes if farming systems</td>
<td>Aquaculture changes the culture pattern from fry/fingerling-rearing to fish culture.</td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Self-confidence</td>
<td>The adoption of aquaculture technology increases the self-confidence of the farmers’ family; they receive improved training on management. This also increases the capacity and understanding of the value of technical inputs.</td>
</tr>
<tr>
<td>Social relationships</td>
<td>Aquaculture helps expand the social network of farmers. New relationships can emerge, through marriages and friendship. Farmers visit fishery officials for technical advise and vice-versa.</td>
</tr>
<tr>
<td>Better use of waste</td>
<td>Household waste, poultry droppings and compost are used as feed and manure.</td>
</tr>
<tr>
<td>Religion</td>
<td>Religious factors sometimes affect aquaculture negatively. Appropriate training can improve this situation.</td>
</tr>
<tr>
<td>Information</td>
<td>Information is crucial during fish disease outbreaks, scarcity of fry/fingerlings exists, limited marketing, etc.</td>
</tr>
<tr>
<td>Access to resources</td>
<td>Access to resources is fundamental to aquaculture. Multi-ownership of ponds and water resources should be settled amicably.</td>
</tr>
<tr>
<td>Availability of technology</td>
<td>Easily adaptable, demonstrated and tested technologies are precondition to expanding aquaculture.</td>
</tr>
<tr>
<td>Education</td>
<td>Education plays a major role in adopting and practicing new technology. For illiterate farmers aquaculture technology should be made understandable in easy to follow, pictorial guidelines.</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Law and Order</td>
<td>Stable law and order is essential: it reduces the incidence of poaching, poisoning and disturbances.</td>
</tr>
<tr>
<td>Communication network</td>
<td>Good communication network, i.e., roads and transportation facilities is also beneficial in promoting aquaculture.</td>
</tr>
<tr>
<td>Institutional framework</td>
<td>To expand and sustain aquaculture benefits to the society, an institutional framework must be present.</td>
</tr>
<tr>
<td>Health benefits</td>
<td>Fish contains high protein and vitamins and less fat and reduces cholesterol-related and protein-deficient diseases.</td>
</tr>
<tr>
<td>Human capital</td>
<td>The dissemination of aquaculture technology enhances human capital (i.e., knowledge, technical know-how, etc.).</td>
</tr>
<tr>
<td>Use of water resources</td>
<td>Expansion and enhancement of aquaculture brings underutilized water-resources into production: ditches, depressions, borrow-pits and seasonal waterbodies.</td>
</tr>
<tr>
<td>Demand driven</td>
<td>Aquaculture should be demand driven otherwise losses are inevitable.</td>
</tr>
<tr>
<td>Interest/willingness</td>
<td>Willingness to undertake aquaculture as well as interest to adopt new ideas and/or technologies are important.</td>
</tr>
</tbody>
</table>
Involvement of Women in Small-Scale Aquaculture

Aquaculture is the fastest growing food sector in Asia. However, the vital role of women in aquaculture growth has not been adequately recognized. Many issues remain inadequately addressed. To ensure sustainability, it is necessary to understand issues related to both men and women and develop gender-sensitive interventions.

Women and aquaculture

An ethnic women’s group organized by CARITAS Bangladesh (with 18 members) in Pagalpara, Mymensingh district, has been practicing aquaculture successfully for the last five years. All aquaculture-related activities such as the excavation of four ponds, stocking, harvesting and marketing are done by the women themselves. Hatchery and market accessibility contributed to their success. The group makes an average profit of US$49/member/year in a pond area of 0.34 ha. Though there are no strictly assigned gender-specific roles in aquaculture, work that involves heavy labor such as pond digging and harvesting is led by men. Women, on the other hand, lead activities such as stocking, feeding, fertilization and routine caring of pond. These roles interchange in different cultures and family environments.

Traditionally, women have been involved in different stages of small-scale aquaculture. They are active caretakers of fish in homestead ponds, cages or even in rice fields. The role of women has been especially prominent when the systems are located close to their homesteads. Restricted mobility, due to religion or security concerns, is a reality that must be considered.
Benefits of women’s participation in aquaculture activities

- Increased fish availability for family consumption, thus benefitting nutrition.
- Improved economic situation of the family resulting from increased fish production.
- Upliftment of social status attributed to adoption of new technologies.
- Children’s education sustained because of improved family incomes.
- Enhanced social capital by establishing good relationships within the community (e.g., providing information to other women).
- Productive use of time without adding much to the existing workload.
- Increased status and participation in various decision-making process within the family.

Gender issues that hinder women’s participation in aquaculture activities

Societal and cultural issues can affect the participation of women in aquaculture. These issues need to be addressed through the formulation of plans suitable for various social and cultural environments.

- Restricted mobility limits the productive contribution of women. Mobility varies with different cultures, religion and societies.
- Apart from restricted mobility, norms in some societies limit women’s contribution in economic activities.
- Men generally participate (and dominate) in trainings and cross-visits, excluding women from access to information and from the decision-making process.
- In many places women have very limited or no land ownership, limiting both access and control over the resources.
- Many agencies aim to improve women’s status by increasing their access to credit. However, credit is not always accompanied by provision of skills. Hence,
women serve only as a conduit for men to procure loans.

- Low literacy rates among women in many countries hamper information acquisition.
- Very few organized women groups exist to articulate the needs of rural women involved in aquaculture.
- Lack of sensitivity to and respect for gender roles and responsibilities is a common problem.
- Data on women involvement in aquaculture is not available, and policies and programs often are not gender sensitive.

**Implemented strategies to address gender issues**

**Family approach**

The family approach was found to be successful because it answers the problem of not having adequate female participation. Both husband and wife take part in training. In conservative communities, early meetings with the family guardians proved effective in ensuring participation of female family members in training sessions. Establishing trust between the extension staff and villagers is also important.

"Farmer field school" with family approach

In the "farmer field school" approach adopted in some of the CARE Bangladesh Agriculture and Natural Resource (ANR) projects, both male and female groups meet separately (due to cultural restrictions) for sessions held every two weeks. Results indicate that this approach helps women acquire knowledge that enables them to take active part in decision-making.

**Gender day**

After the first few sessions (conducted separately with male and female groups), both groups are brought together on a day designated as their “Gender Day”. On that occasion, discussions of gender issues and local problems take place, and
action plans are developed. Later, a midterm review is conducted and necessary adjustments are made. At the end of the season, the groups meet to examine the progress and set new goals.

After the learning sessions (held once or twice a month), focus on gender issues is ensured. Information materials are used to create awareness and effect changes in perceptions and attitudes of both men and women.

### Change in decision-making pattern in family

A study conducted in the New Options for Pest Management (NOPEST) project of CARE Bangladesh indicated that gender awareness programs significantly influenced the decision-making process in the family. In the first season, a survey indicated that only about 44% of the men consulted their wives in making different decisions. However, at the end of the third season, more than 92% of the men reported that they consulted their wives in decision-making.

### Access to information

All women may not be able to attend training. For those women who fail to attend training sessions, individual attention and support have been found to be useful. During the sessions, interaction among women participants is encouraged. Fixing targets for each woman to train other women in the community on the techniques
and social issues discussed have shown good results.

Sample issues discussed after the learning sessions
- People's reaction to the birth of a baby girl
- Attitudes towards boy and girl
- Recreation time for male and female members
- Decision-making process in the family
- Barriers to women development in families
- Gender-based labor division
- Health of women
- Family conflict
- Savings utilization
- Recognition of women’s work
- Decline in social values

Gender sensitive technology development

In developing technologies, women’s needs should be considered. Technologies should not add risk to the end-user and should be women-friendly.

Gender sensitive technologies
In Cambodia, termites and other available feed resources are used as fish feed. However, Cambodian women treat the task of termite collection as an additional work load. Moreover, because of security concerns, they are unable to move freely to collect termites. Instead, the green water technology, which is effective in promoting the growth of plankton feeding fishes, was preferred by women. They understood the benefits of this technology in influencing fish growth and began to advocate plankton as fish food comparing its effect to that of "mother’s milk to baby".

In Bangladesh, several women are involved in making prawn/fish feed at home for their own use. It has also become an important income generating activity as they can sell feed to other farmers in the area. Women are comfortable making feeds as they already know how to make rice noodles. In fact, they use the same noodle-making machine to make feeds.

Input supply
Since mobility of women is sometimes restricted, the development of technologies emphasizing the use of available resources in the farm is especially suitable for women. When external inputs are necessary, they should be available in accessible places.

**Division of labor**

Care should be taken to avoid giving women additional work. Proper planning by family members (in a threat-free environment) of the daily activities and labor distribution reduce the burden on women and increase efficiency.

**Gender sensitive extension staff**

In many countries, there are very few female extension staff members. Male extension staff generally tends to serve primarily the needs of men. However, the provision of gender education to staff has been found to be useful in changing that attitude.

Studies conducted in different countries indicate that women work longer hours than men. Gender sensitization activities should enhance awareness of this issue in order to bring changes in work distribution.
Staff composition
Depending on the local situation, having male and female extension officers might be a useful way to adequately reach women. A gender balance in extension staff recruitment is one of the strategies that have been tried successfully in many projects of CARE and CARITAS Bangladesh. To attract women, reserve positions for them. Development of gender sensitive policies and enforcing them with the active participation of staff have helped ensure gender sensitive outcomes.

Credit systems
Credit, coupled with appropriate training, is usually helpful to farmers. In some countries, like Bangladesh, existing micro-credit systems have inappropriate repayment schedules. Most aquaculture species require a three to four months grow-out period. But the existing credit system requires commencement of repayment within a week after the loan is obtained. Changing the repayment schedules has been found to benefit women involved in aquaculture activities.

Credit systems need not depend only on available credit facilities. Established women’s groups should initiate the formation of a self-help credit system for themselves. Each woman member can contribute an equal amount of seed money which they can avail of alternately. That way, money procurement is facilitated and interest is avoided.

Small aquaculture systems help improve the livelihoods of people. The provision of knowledge to fish farmers, particularly to women, contributes to women empowerment and an increase in family income.
Prepared by:
Anwara Begum Shelly,
M. C. Nandeesh and A.K.M. Reshad Alam
Impact of Aquaculture on the Environment

Most of Asia’s aquaculture development took place over the last few decades. This is evident by the 244 percent increase in aquaculture production in Asia from 1986 to 1994. Aquaculture has many positive impacts on the environment. But it also has negative impacts, which often occur when there is overexploitation of environmental goods and services. The more intensive the operation, the greater the demands on the environment. This article discusses in depth some of the negative consequences.

Positive impacts on the environment

Although aquaculture contributes a lot to improving the environment, the positive impact on the environment is not often realized (and documented). Some of these are represented below.
Negative impacts on the environment

1. Loss of ecologically sensitive habitats

Coastal pond aquaculture, whether used for extensive shrimp culture, semi-intensive or intensive aquaculture, has been blamed for large-scale losses of mangroves and mud flats in several countries (e.g., Thailand, Indonesia, Philippines, Vietnam, etc.).

Though shrimp aquaculture is blamed for the destruction of mangroves, huge areas of mangrove vegetation in Asia were also lost due to community development, agriculture, road and ports development, salt producing farms, mining, charcoal, fuel, wood extraction, etc. On the other hand, important wetlands, including keystone habitats, have been altered for aquaculture purposes. The alteration of coastal and inland habitats has negative impacts on fish and other aquatic organisms.

Keystone habitats are relatively rare but are ecologically significant.

Silvofisheries is an integrated mangrove tree cultivation with brackish water pond aquaculture.

<table>
<thead>
<tr>
<th>Areas of shrimp culture in former mangrove areas in Asia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Farm</td>
</tr>
<tr>
<td>Extensive</td>
</tr>
<tr>
<td>Semi-extensive</td>
</tr>
<tr>
<td>Intensive</td>
</tr>
<tr>
<td>Total area</td>
</tr>
</tbody>
</table>
General practices in protecting sensitive wetland habitats, as practiced in coastal pond aquaculture

<table>
<thead>
<tr>
<th>DOs</th>
<th>DON'Ts</th>
</tr>
</thead>
<tbody>
<tr>
<td>■ Retain mangrove patches between ponds and inlet water sources.</td>
<td>■ Do not use mangrove vegetated soil. It is not suitable for pond aquaculture due to its acidic nature and the extensive root system of the mangroves.</td>
</tr>
<tr>
<td>■ For extensive practice, use relatively small pond areas.</td>
<td>■ Do not use large areas for extensive shrimp culture.</td>
</tr>
<tr>
<td>■ To compensate for the reduction in pond area, utilize improved management interventions to increase productivity.</td>
<td>■ Do not encourage coastal aquaculture systems with low productivity in large areas.</td>
</tr>
<tr>
<td>■ Encourage silvofisheries model of alternating pond with mangroves.</td>
<td>■ Do not open new areas of mangroves for conducting pond aquaculture, except under exceptional circumstances.</td>
</tr>
<tr>
<td>■ Practice pond aquaculture in former mangrove areas.</td>
<td>■ Do not encourage coastal aquaculture in mangrove areas without alternating with mangroves.</td>
</tr>
<tr>
<td>■ Recognize mud flats as important feeding habitat for migratory birds and various aquatic organisms and other wildlife.</td>
<td>■ Do not convert mud flats into aquaculture ponds.</td>
</tr>
</tbody>
</table>

2. Deterioration of water quality and the reduction in carrying capacity of the aquatic environment

As aquaculture becomes more intensive, the amount of wastes released into the environment, especially in surrounding waterways, increases. Wastes enter the environment in the following ways:
- Direct effluent loading due to water exchange.
- Pond bottom sludge removal.
- Effluent water discharged into the source of water intake.
- Waste production from cages in lakes, reservoirs and marine environments
- Excess feeding, animal feces and uneaten food, which settled at the bottom of the cage and pen.
- Use of fresh fish rather than pelleted feeds as food

Source: Beveridge et al., 1997.
The higher the intensity of aquaculture, the more waste is accumulated. In the case of shrimp farm effluent, pollution loading is considerably less than from domestic or industrial waste. Although chemicals released into waterways can and do have an impact on water quality, the use and release of chemicals in aquaculture are less than in agriculture and most, but not all, are only marginally harmful to the environment.

### Impact of waste and nutrient loading on the environment

- Can cause eutrophication of waterways leading to plankton crashes and depletion of oxygen
- Self-pollution of aquaculture systems
- Increase in the concentration of ammonia and a reduction of oxygen in the waterways reducing the carrying capacity of aquatic environments
- Excessive development of inland cage culture causes more significant reduction in the carrying capacity of the aquatic environment than pond aquaculture

### General practices in discharging effluent and maintaining water quality, as practiced in aquaculture

<table>
<thead>
<tr>
<th>DOs</th>
<th>DON'Ts</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>If effluent is not very abundant, discharge effluent water through a wetland area. Wetlands efficiently absorb and retain nutrients and organic matter from overlying waters.</td>
<td>Do not discharge effluent water directly into the waterways.</td>
</tr>
<tr>
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</tr>
<tr>
<td>If wetlands are not available, discharge effluents into a pit or depressed area or into a settling pond to store it for a period of time before releasing it. If in coastal areas, release after storing with rain water, to reduce the salt content.</td>
<td>Do not discharge effluent water without allowing the suspended matter to settle.</td>
</tr>
<tr>
<td>In coastal areas, the disposal of effluents into mangroves located away from open waterways can be undertaken in order to exploit the capacity of mangrove soils to serve as &quot;sinks&quot;.</td>
<td>In coastal areas, do not dispose of effluents into mangrove areas that are very close to open water ways and may transport nutrient load directly to the open sea. This might cause eutrophication.</td>
</tr>
<tr>
<td>Dry the pond bottom between two culture cycles to increase the microbial degradation of accumulated organic matter and to oxidize substances in reduced states.</td>
<td>Do not start the next culture cycle without observing a fallow period, which depends on how long it gets the pond to dry.</td>
</tr>
<tr>
<td>In coastal areas, use the shrimp pond waste sludge in the inter-tidal zone to fertilize mangroves.</td>
<td>Do not dump waste into non-salt tolerant agricultural lands, as it will contaminate the soil and kill plants.</td>
</tr>
<tr>
<td>Explore possibilities for using pond waste sludge to produce fertilizers for vegetable cultivation.</td>
<td>N/A</td>
</tr>
<tr>
<td>For cage culture, allow a 2 m distance between the bottom of the net cage and the bottom of the water body to minimize pollution and to allow nutrient recycling.</td>
<td>Avoid using fixed submerged cages, if it is not possible to retain a 2 m distance between the bottom of the net and the bottom of the water way.</td>
</tr>
<tr>
<td>Determine the carrying capacity of the aquatic environment before expanding aquaculture activities.</td>
<td>Do not allow uncontrolled expansion of aquaculture activities.</td>
</tr>
</tbody>
</table>

3. Loss of agricultural land and salinization
The lucrative nature of shrimp aquaculture has led to the conversion of many paddy fields and coconut-cultivated land into ponds. The innovation of inland culture of marine/brackish water shrimps has led to the conversion of rice paddy lands into ponds. The main environmental issues are the potential salinization of soil and fresh water wells as salt intrudes into ground water in coastal and inland areas after it is transported and added into the ponds. While economic returns are higher in shrimp aquaculture, the value of lost rice crops or coconut cultivation could become very high as they become scarce.

General practices in protecting agricultural areas and preventing saltwater intrusion, as practiced in pond aquaculture

<table>
<thead>
<tr>
<th>DOs</th>
<th>DON'Ts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use suitable sites for aquaculture according to the accepted site selection procedure. Utilize marginal and unproductive lands for aquaculture.</td>
<td>Do not use fertile agricultural lands for salt-based aquaculture that has the potential to impact the neighboring farms or the environment.</td>
</tr>
<tr>
<td>Avoid inland areas for salt-water aquaculture.</td>
<td>Do not transport salt into inland areas in order to practice salt water aquaculture.</td>
</tr>
</tbody>
</table>

4. Loss of ground water

- Ground water extraction is being done to dilute saline water in ponds where aquaculture is undertaken for low salinity tolerant species.
- Ground freshwater extraction in large quantities may lead to land subsidence.
- Ground freshwater extraction can lead to conflicts between users, for example agriculture and domestic ground water consumers.

General practices in protecting ground water resources, as practiced in pond aquaculture in saline areas

<table>
<thead>
<tr>
<th>DOs</th>
<th>DON'Ts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adopt a switch over strategy to culture high saline tolerant species in high saline areas.</td>
<td>Do not use low saline tolerant species in areas where high salinity prevails.</td>
</tr>
</tbody>
</table>
5. Spread of diseases

Diseases could be spread from one aquaculture system to another and to the wild. Disease is a very serious concern both for aquaculture and wild aquatic organisms. The use and sometimes abuse of antibiotics in more intensive farming has led to multiple drug resistance among pathogens, facilitating the spread of diseases. Every effort should be observed to control and prevent transmission of diseases.

6. Introduction of exotic species

The introduction of non-native fish species into the wild through aquaculture may lead to a serious problem in the long run.

- The golden apple snail, introduced for aquaculture, has become one of Asia’s most serious rice pests.
- Captive aquatic animals inevitably escape and can colonize natural waters: an estimated two-thirds of species introduced into tropical inland waters have become established, although many had positive economic benefits.

- Exotic species (African catfish, tilapia and silver carp) in inland water could pose such risks as habitat destruction, elimination of local species by competition or predation, and genetic degradation of local stocks. All this results in a loss of biodiversity.
- The introduction of genetically modified organisms (GMOs) can cause ecological damage and imbalances.
- Introduced strains can alter the gene pool of indigenous species, leading to genetic pollution and the loss of indigenous organisms and biodiversity.
- The accidental release of piranhas in Sri Lanka and
Vietnam and knife fish in Sri Lanka into natural water ways is now a serious environmental concern. The fish were obtained for ornamental fish breeding and culture farms.

<table>
<thead>
<tr>
<th><strong>DOs</strong></th>
<th><strong>DON'Ts</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Identify and promote native fish species for aquaculture.</td>
<td>- Do not introduce exotic species, which have the potential to cause a negative impact on the environment.</td>
</tr>
<tr>
<td>- Review strategies associated with the use of exotics and GMOs for aquaculture and further develop practical codes for risk assessment and management, as emphasized in the FAO Code of Conduct for Responsible Fisheries.</td>
<td></td>
</tr>
<tr>
<td>- Focus attention on implementation of strategies/actions by signatories to the Convention on Biological Diversity. Check the prohibited or restricted list of species before using them for culture.</td>
<td>- Do not culture or introduce prohibited or restricted species.</td>
</tr>
</tbody>
</table>
Major management considerations for environment-friendly aquaculture
(ADB/NACA, 1995)

Prepared by:
P.P.G.S.N. Siriwadena,
Michael J. Phillips and Ian G. Baird
Conservation of Aquatic Genetic Diversity

Genetic variation within a population allows the species to adapt to environmental change or stress. It is important for the populations to be able to reproduce, survive, and successfully evolve in a changing environment. Populations with higher genetic diversity are more likely to have at least some individuals that can withstand uncertain changes of the environment. They can pass these genes to future generations. Genetic diversity has been shown to have a positive relationship with measures of fitness such as growth, fecundity and survival. It should be conserved because it is a fundamental component of adaptation and evolutionary success.

Foods

In the fields of fisheries and aquaculture, conservation and utilization of genetic diversity are important as aquatic animals, including fish, are major food sources harvested from natural populations. Genetic diversity is very important in a species being bred for desirable traits. Likewise, it provides the foundation for the rapidly growing biotechnology industry.

Medicines and tools for biomedical research
Long before the birth of modern medicine, shamans and herbalists have used aquatic organisms as medicines. The aquatic environment is home to many animal phyla that are not found on land, so its biochemical diversity is great. The pharmaceutical potential of aquatic organisms is very high especially in the tropics. Kelp is a very good source of iodine. Cod and shark liver oils were used as sources of vitamins A and D before other sources were developed.

**Genetic diversity and stock enhancement**

Dwindling aquatic resources led to the development of hatcheries for rearing and releasing juvenile fish. Some populations of Pacific salmon are dependent upon hatchery seed. Stock enhancement is also being considered to rebuild the depleted stocks of the abalone and tuna. The following are some approaches that can minimize the loss of aquatic genetic diversity:

- The genetic structure of the hatchery stock should be as close as possible to the genetic structure of the wild population. Negative genetic impact is likely to occur when there are big genetic differences between the hatchery stock and the wild population.
- Use a large number of parents. The use of very few parents in the hatchery to produce numerous seeds for release into the wild also increases the risk of loss of genetic diversity.
- Avoid introduction of alien fish into the wild. Local varieties can be genetically contaminated if different varieties of even the same species are introduced into the wild to enhance natural stocks. Import of exotic breeds is one of the reasons for the disappearance of local breeds.
- Do not release seeds from stocks that have been made to adapt to hatchery conditions. The genetic changes, which occur in cultured fish, are expected to lower their reproductive success in the wild, as well as their offspring. Hatchery-reared fish also increase the spread of infectious diseases and parasites to wild fish.
The introduced eleotrid *Hypseleotris agilis* led to the local extinction of the endemic cyprinids of Lake Lanao, Philippines.

The introduction of the nile perch *Lates niloticus* dramatically reduced the fish biodiversity of Lake Victoria, Africa.

**Genetic strategies for use in aquaculture hatcheries**

The aim of aquaculture hatcheries is to select seeds that have specific production traits and should not be used for stock enhancement.

Some strategies that can be adapted to avoid inbreeding and loss of diversity

- Use a large number of parents. This becomes a problem in highly fecund species such as Indian and Chinese carps, where only a few broodstock can easily meet fry production needs. The general recommendation, for short-term period, is to use 50 males and 50 females.
- Keep the sex ratio as narrow as possible. The best effective population size can be obtained by a ratio of 1:1.
- Avoid mating of closely related individuals.
- Use a rotational mating scheme. This minimizes relatedness of parents.
- Avoid accidental release of fish from culture facilities. Culture of fish results in divergence from the wild type. Genetically altered fish from culture facilities represent a threat to the genetic diversity of wild populations.
- Avoid mixed spawning of different species.

**Threats to aquatic genetic biodiversity**

Biodiversity is being lost from nearly all aquatic ecosystems at an alarming rate due mainly to the rising human population and anthropogenic processes associated with development. The three major threats to genetic diversity within species include extinction, hybridization, and loss of genetic variation within and between populations.
Options for the conservation of aquatic genetic diversity

The conservation of aquatic genetic resources should be addressed in developing countries even if the immediate concern is to increase food production. It is feared that the genetic diversity of aquaculture species will decline as new improved breeds of fish are spread worldwide, replacing locally cultivated landraces and the remnants of wild populations.

Ex situ genetic conservation in gene banks
Ex situ conservation is the maintenance of a genetic resource either as frozen sperm, eggs or embryo in gene banks or as samples of living breeds in a secure environment. A national gene bank for salmon was established in Norway for the Norwegian wild Atlantic salmon. More recently, gene bank for tilapia has also been established in the United Kingdom. Ex situ conservation may not be feasible in developing countries because of the large amount of genetic diversity available and the expensive maintenance of collection.

On-farm genetic conservation

One conservation option for developing countries is on-farm in situ conservation of genetic resources. An important feature of sustainable, on-farm genetic conservation is that relatively simple genetic technologies can be used to develop a variety of aquaculture breeds specially adapted to local conditions and diverse farming systems. For example, a simple farm-based tilapia selection procedure developed by SEAFDEC, Philippines with a tilapia farmer using locally available tilapia breeds generated a 6-9% response to selection for increased length, after only one generation of selective breeding.

Use of local breeds adapted to local conditions is a conservation tool that allows the maintenance of multiple qualities. Likewise, this will minimize the dependence of farmers on a franchise-dealer type of seed distribution. In the desire of developing countries to increase fish production, perceived superior breeds of fish are often imported. Local and (frequently) better adapted breeds for local conditions are displaced.
References


Prepared by:
Zubaida Basiao
Development Assistance for Small-Scale Aquaculture

People who want to start or improve small-scale aquaculture activities often look for help in the form of better information or financial assistance. An extension agent, even a generalist, should be alert to opportunities to steer these people towards good information based on their knowledge of possibilities and resources available.

Means to develop assistance for small-scale aquaculture
● **Appropriate extension literature should be available.** This could include “how to” information, lists of sources of seed stock or production inputs, etc. The literature has to be simple and well illustrated for easy understanding. Much extension literature has already been developed and could be adapted to local conditions, including translation into the local language. Likewise, centrally located subject matter specialists with more specific technical knowledge could produce bulletins, leaflets and other teaching aids with the help of media specialists.

● **Rural banks have to prepare for loan applications for small-scale operations.** Many poor people cannot borrow for lack of collateral to back up their loan requests. Sometimes, seed sellers or other suppliers can also serve as sources of informal credit and production information, especially when they want borrowers to succeed and be able to repay their loans. In some settings, groups have been formed with savings plans or credit guarantee capacity that have helped people enter into small-scale aquaculture enterprises. Caution is needed because some lenders may impose unreasonable conditions on loans or charge usurious rates for credit.

● **Extension workers should promote proven practices adapted to local conditions.** An important extension responsibility is to dissuade people from ill-advised schemes not founded on valid principles.

● **People need to know where and how to access available technical support.** Aside from government programs, literature or advice on how to use products or services may be provided by feed retailers or other related businesses.

● **Where aquacultural development has been targeted, specific projects are in place to provide assistance, often with support from international donor**
organizations. The nature of such projects varies and care is needed to ensure that support systems provide assistance on a long-term basis and not merely for the duration of the project.

- **Group teaching, learning and participatory opportunities should be explored.** Producer organizations are often helpful and special programs involving women need adequate consideration. Some of the most successful technology transfers have occurred when extension workers facilitated the formation of groups where producers can share information and seek collective representation in addressing their needs.

- **Media campaigns through radio, television and newspapers often generate interest if accompanied by information about where and how a person can get further assistance.** Posters, large signs or small signs on demonstration ponds can get attention. Traveling folk theater presentations have been used in some cultures. Even portable loudspeaker systems passing through communities, a process called “miking”, has potential for communicating in rural areas.

- **School curriculum models can create public awareness.** Children often bring information to their families. They represent the generation of future aquaculture adopters. Children may also have the reading and computational skills lacking in older generations. They can apply these skills to family fish farming operations.

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Caritas-Bangladesh organized 17 landless farmers in Rajshahi District who were interested in starting an aquaculture enterprise. The group met fortnightly and contributed a small fee at each meeting for the training received from Caritas. After a few months, the group had built up enough funds to lease a 4,000 sq m pond, with Caritas advancing 80% of the credit needed. The operation was so successful that the group quickly expanded their operation by adding three additional ponds. The group was also able to start a small fish hatchery through Caritas’ encouragement, training, and credit support. Five years later, the group had repaid all its loans. Now, it operates 11 ponds and a commercial fingerling nursery system using seed from its hatchery. It employs three full-time laborers to assist in maintenance of facilities.
Research agencies need to participate in outreach programs. Such participation helps researchers learn the real problems faced by producers and where research efforts need to focus.

Prepared by:
John Grover
Introducing Aquaculture into Farming Systems: What to Look Out For

Integrated farming systems have been the subject of extensive research because of their socio-economic, institutional and environmental implications. If aquaculture is considered as an additional component of a farming system, a re-assessment of the system’s conditions is necessary, especially if aquaculture is not a traditional pursuit.

The guide questions presented in this paper are aimed at farming communities. However, they can be adapted to other situations like river, estuary, and marine communities.

Unfortunately, there is no quick and easy blueprint on how to successfully integrate aquaculture into the diverse range of smallholder farming systems. Social, economic, cultural, institutional and environmental factors vary between places and will always need careful study and understanding before aquaculture can be introduced into existing farming systems. In China, where people have been successfully integrating aquaculture with other farming systems, the setup evolved in harmony with specific social, economic and cultural conditions. If these specific systems were to be transferred to other regions, there is no guarantee that they would succeed due to different resource availability, know-how and traditional farming practices.
Below are some of the important considerations in integrating aquaculture into smallholder farming systems:

**Sufficient incentives**

- Are fish part of the diet of farming households? Are fish an important food item in the community? If so, where do the fish come from - capture or culture? At what price? Is there a perceived need for additional fish?
- Would aquaculture fit well into the existing farming system? Would it make use of and complement the existing crop and livestock activities? Would the aquatic produce improve the nutritional status of the farming household? Would aquaculture be a new income source in addition to existing ones (e.g., poultry, ducks, livestock, vegetables and plant nursery)?
- Can the produce be marketed at relatively low cost? Can poorer consumers afford it? If the product is consumed at home, does it substitute for a good or item that would otherwise have to be purchased by the household?
- Would the additional income derived from aquaculture be sufficient incentive for the farmer to make the additional investments in terms of money, labor and time?
- Do farmers have access to the market? Is it easy to bring produce to the market? Do price structures provide for economic feasibility, considering instrumental and operational costs? Are there alternative/wider market implications? Are there other markets – nationally or internationally – that may be tapped?

**Sufficient resources**
• Are there sufficient farming systems resources (labor, water, land, initial capital, etc.) to support an additional aquaculture component? What are these resources? Can aquaculture replace an existing farming system component and provide more returns with equal or less opportunity costs?

• Will the use of natural resources for aquaculture take away resources that are important for wild capture fisheries or aquatic biodiversity?

• Are the natural resources necessary for aquaculture being shared by other users? Could this create conflict between users?

• Is credit needed? Would it be available at interest rates affordable to the farmers?

Sufficient know-how

• Is there sufficient know-how within the household to successfully manage an aquaculture component? Is it available from outside on a sustainable basis or can it be brought in from outside?

• What are the skills/knowledge required? Is the technology robust, simple, easy to use and appropriate to farmers’ capacity? Are farmers likely to sustain adoption?

• Will the acquisition of knowledge and skills involve all members of the farming household?

• Do local people/government know about potential impacts of aquaculture on other aquatic resources? Can they control the situation to avoid or mitigate potential impacts?

Reliable supply of production inputs

• Are essential inputs, such as fish juveniles or breeders, feed and fertilizer locally available? Are these inputs available at costs that will make production economically viable?

• Are there sufficient surplus agricultural products that may be used in aquaculture as inputs? Are they available on-farm? Do they have to be purchased? If so, is there an affordable and reliable supply?

• If juvenile/small fish are being used as feeds, does this practice have ecological and/or social implications (e.g., diminishing the natural food for
other native fish species or as food for poor disadvantaged people)?

Reliable and effective development support

- Is development support for aquaculture available and accessible to the farmer? Is it reliable and efficient?
- What are the costs involved in receiving this support? Who will pay? Can it be delivered on time and is it cost-effective?
- Is there sufficient government support in terms of extension work and training? How could the private sector be involved? Does the farmer have the capacity to consider all aspects in a balanced manner pertaining to aquatic resources use and management?

Sufficiently developed and stable market

- Is there sufficient and stable demand for the produce? Can peak harvests be absorbed?
- Can peak harvests and periods of low supply and related market problems be avoided by culturing several species throughout the year?
- Will the setting up or use of present cooperatives (community based operation) facilitate marketing?
- Does communication support quick marketing? What processing or preservation alternatives are there? Are there any value-adding opportunities?
- Will the increased availability of aquaculture fish result in decreased value of natural fish? Will it impact those who harvest wild fish?

Social and cultural factors

- Is the inclusion of aquaculture in the targeted farming system socially and culturally acceptable? Does aquaculture conflict with given value and behaviour patterns (e.g., sense of ownership or negative impacts of livestock-fish integration) on religious norms (e.g., in Muslim societies)?
- Can it create new problems regarding the existing resource use system?
- Does it imply changes in existing production systems, for example from individual farming-based systems to collective production? Or can it have negative consequences for the existing gender specific division of labor system, for example, by putting additional burden on women? Will it inadvertently promote the use of cheap child labor?
- Will an introduced technology change the distribution of control, decision making or sharing of benefits within the household (gender and age consideration)?
● Is there a potential for social conflict because of the multiple use of resources?
● Would management practices of neighboring farmers affect introduced aquaculture, e.g., through the use of pesticides?
● Are the beneficiaries convinced and committed to improve their status (health and income, empowerment through aquaculture)
● Is the fish culturally important to the community?
● If aquaculture is community-based, would it be possible to go for social action establishing human right/equity after the project?
● Do the beneficiaries have other alternatives to allow the fish to grow?
● If the resources are common property, how can they be accessed for aquaculture? Are there opportunities for aquaculture to provide a focus for communal efforts (seed supply, training, sharing labor, etc.), which can enhance social relationships? Will aquaculture options resolve existing conflicts by providing a forum for people to reach consensus on resource allocation or use?"

● Land ownership

Environmental factors

● What are the potential environmental impacts (carrying capacity of the local resources)?

Prepared by:
Matthias Halwart and Julia Lynne Overton with workshop participants
Rice often constitutes up to 60% of the daily food intake of most Asians. It is often the major source of energy and nutrients in their diet. However, only traces (and sometimes none at all) of some essential nutrients like Vitamins A and C, iron, calcium, zinc and iodine are found in rice. These nutrients, therefore, must be supplied by other foods. The relationships among food, energy and essential nutrients must be seriously considered in order to ensure food and nutrition security.

The "Green Revolution" averted some problems of starvation. But efforts to increase the production of staple cereals, and the energy and protein that they provide, failed to address health problems related to nutritional deficiency. Advances in agricultural production have, therefore, not been clearly linked to human nutrition and health needs. The problems of malnutrition and health, to a great extent, can be addressed by improving access to quality and diverse food types. Fish has the potential to ensure a quality diet.

<table>
<thead>
<tr>
<th>Diet-related health problems in developing world</th>
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<tbody>
<tr>
<td><strong>Problem</strong></td>
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<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Insufficient food</td>
</tr>
<tr>
<td>Low birth weight (&lt;2 kg.)</td>
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<tr>
<td>Vitamin A deficiency</td>
</tr>
<tr>
<td>Anemia</td>
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<tr>
<td>Goiter</td>
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</tbody>
</table>

* Other deficiencies, notably those of energy, protein, calcium and some vitamins (e.g., Vitamins A and C, riboflavin) also contribute to
many of these and other less widespread problems of malnutrition.

Source:

Fish protein

- Fish protein is of high quality as it contains all the essential amino acids necessary for physical growth and maintenance.
- It is highly digestible (85 - 95% digestibility) and has favorable taste.

In Bangladesh, only 6% of the daily food intake is of animal origin, with fish accounting for about 50%. By contrast, rice constitutes 60% of the daily food intake and contributes 78% of the protein in the diet (Ahmad and Hassan, 1983). But rice protein is poor in lysine, an essential amino acid. Hence, rice protein must be supplemented with lysine from fish protein. The combination would provide a high quality protein diet.

Fish oil

- Most fish are relatively low in total fat and relatively high in polyunsaturated fatty acids. Polyunsaturated fatty acids, such as omega-3 fatty acids in fish oil, have been found to decrease blood triglyceride and cholesterol in animals and humans. Thus, adequate consumption of fish helps maintain a healthy heart and lowers the risk of stroke and heart attack.

Vitamins and minerals

- Fish is a fairly good source of fat and water soluble vitamins. Vitamin A is present in fish as retinol, which is readily absorbed and utilized by humans. In vegetables, Vitamin A comes as B-carotene, which is not as readily absorbed as retinol and, to some extent, is lost in cooking. Among the local fish in Bangladesh, Mola (Amblypharyngodon mola) and Dhela (Rohtee cotio) stand out as rich sources of Vitamin A.
- Fish contributes enormously to the mineral supply in the diet. Minerals such as iron, copper, zinc, magnesium, calcium and phosphorus are essential for several vital metabolic functions of the body.
A meal with 23 g of Mola can supply the recommended daily dietary allowance of a 4-6 year old child and can prevent him going blind.

- Iron is necessary for hemoglobin formation in the blood. Unlike iron in rice and other plant sources, fish iron is more readily available. Moreover, fish protein improves the utilization of rice iron for hemoglobin formation. Thus, when taken together, fish and rice enhance hemoglobin formation in the blood and can therefore address the problem of iron deficiency or anemia.

- Calcium and phosphorus are essential for bone formation. Small fish, that can be consumed with their bones and heads, constitute good sources of these minerals. In Bangladesh, small fish are important calcium sources as milk and milk products make up only a small portion of the diet.

- Iodine deficiency is a major problem in Bangladesh causing goiter and cretinism and retarding growth. About 70% of the population are deficient in iodine, of which 47% have goiter with 9% having visible goiter. The goiter rate was reported to be higher (51%) in flood prone areas.

Recent studies conducted in both rats and humans showed that small fish was as good a calcium source as milk.

Small indigenous species (SIS)

Fish and rice constitute the major components of the Bangladeshi diet. But majority of the fish eaten by the rural poor are the small indigenous species (SIS) that grow to a maximum length of about 25 cm. However, many SIS are less than 10 cm. long (Felts et al, 1996) and are typically eaten whole, with organs and bones. Analysis of SIS showed that they contain large amounts of (often limited) micronutrients and minerals.

<table>
<thead>
<tr>
<th>Vitamin A, Calcium and Iron Content in fish</th>
<th>Vitamin (ug)</th>
<th>Calcium (mg)</th>
<th>Iron (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fish species (per 100 g raw, edible parts)</strong></td>
<td></td>
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<td></td>
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<tr>
<td><strong>SIS</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Mola (Amblypharyngodon mola)</td>
<td>1960</td>
<td>1071</td>
<td>7</td>
</tr>
<tr>
<td>Dhela (Rohitee cotia)</td>
<td>937</td>
<td>1260</td>
<td>-</td>
</tr>
<tr>
<td>Darkina (Esomus danricus)</td>
<td>1457</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chanda (Parambassis spp.)</td>
<td>341</td>
<td>1162</td>
<td>-</td>
</tr>
<tr>
<td>Puti (Puntius spp.)</td>
<td>37</td>
<td>1059</td>
<td>-</td>
</tr>
<tr>
<td>Kaski (Corica soborna)</td>
<td>93</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Un fortunately, over fishing and deterioration of natural habitats, largely due to indiscriminate use of pesticides, have resulted in a decline in the number of SIS. The importance of SIS is also often overlooked. The species are often called "wild" or "weed" fish and there are no available statistics on them. Agricultural systems, including flood plains, fisheries and aquaculture, must protect and promote the production of small fish along with carps in order to make them accessible in greater quantities for consumption. Nutrition education popularizing the production and consumption of SIS can help enormously in improving food and nutrition security.

### Advantages of utilizing SIS

- Unlike large fish, SIS are eaten in small amounts many days per week thereby becoming a part of everyday diet.
- With a little oil and vegetables, a variety of dishes can be made.
- Small fish are also more equally distributed among family members. With a big fish, the man gets a larger share.

### Future research needs

1. A feasibility study on the polyculture of carps with small indigenous fish species in Bangladesh.
2. Analysis of the nutrient composition of all commonly consumed fish species in Bangladesh.
3. A study on the linkages between fish biodiversity and human nutrition.

### References


Prepared by:

**Nazmul Hassan**
Managing the Introduction of Exotic Species

Globally, introductions of aquatic species have been undertaken on a wide scale. The FAO Database on Introductions of Aquatic Species (DIAS, http://www.fao.org/fi/statist/fisoft/dias/index.htm) has 3,150 records on introductions of 654 aquatic species from over 140 families. Aquaculture is one of the primary reasons for the deliberate introduction of aquatic species. Other reasons include:

- biological control
- trade
- accidental introductions
- establishment of wild populations
- sport and recreation
- research
- forage and bait
- commercial fisheries
- food security
- unknown reasons

**Introduction of species** is defined as the human assisted movement of an organism to an area outside of its present range, so not necessarily crossing national borders.

Examples of introductions
Examples of introductions of exotic species are many. Following are a few examples of introductions of aquatic species, in particular:

- The introduction of ice fish (*Neosalanx tangkahkeii taihuensis*) from Taihu Lake to other lakes and reservoirs in China to exploit the underutilized zooplankton resources, resulted in the rapid establishment of natural populations of this species. For example, the yearly yield in Dianci Lake, where the ice fish was introduced in 1979, increased by an average of 1500 tons.

- The silver carp (*Hypophthalmichthys molitrix*), introduced in the Gobindsagar reservoir in India, improved fisheries production from 160 tons in 1970-71 to 964 tons in 1992-93 (V.V. Sugunan, 1995).

- On the other hand, the introduction of the common carp (*Cyprinus carpio*) into the upland lakes of Kumaon Himalayas, the Dal lake in Kashmir, Gobindsagar and the reservoirs in the northeast of India, led to the extinction of several snow trouts (*Schizothoraichtys nigor*, *S. esocinus* and *S. curvifrons*) from these habitats.

- The introduction of the clupeid fish (*Limnothrissa miodon*) from Lake Tanganyika to Lake Kivu in Africa to exploit underutilized zooplankton resources resulted in the formation of a significant artisanal fishery with an estimated sustainable yield in excess of 13,500 tons per year, apparently with minimal side-effects. Higher benefits have also arisen from the introduction of the same fish into Lake Kariba in Zimbabwe.

- The golden apple snail (*Pomacea canaliculata*), indigenous to tropical and temperate South America, was imported into Asian countries, including Taiwan, the Philippines, Vietnam and Thailand, in 1980s mainly as food for humans. It soon escaped into the wild and attacked rice voraciously. Myanmar, Bangladesh and India, are currently threatened with infestation of this snail (Halwart, 1994).

- The widespread use throughout Asia of tilapia (*Oreochromis* spp.), indigenous to Africa, has resulted in significant aquaculture production of low-cost protein especially for the rural poor. Similar benefits have arisen from the widespread culture of the common carp (*Cyprinus carpio*).

- In other areas, these same fishes are considered noxious pests that disrupt both natural ecosystems and, in the case of tilapia, the aquaculture sector itself, highlighting the complexities of introductions.

- Introductions have been used successfully to help control nuisance aquatic species. For example, grass carp (*Ctenopharyngodon idella*) is used to control submerged weeds in lakes, reservoirs and irrigation canals. The introduction of
snail eating fishes and mosquito fish (*Gambusia affinis*) assisted in the control of vectors of major water-borne diseases, like schistosomiasis and malaria.

- Results of an introduction are not completely predictable nor always positive. Introductions are now considered among the main threats to natural aquatic populations. The introduction of Nile perch (*Lates niloticus*) into Lake Victoria, Africa, changed primarily small-scale artisanal fisheries into multi-million dollar commercial fisheries that support industrial processing and export ventures, but threaten to make extinct several hundred indigenous species of fish. Similarly, the accidental introduction of *Hypseleotris agilis* in Lake Lanao in the Philippines led to the extinction of most endemic cyprinids in the lake.

- Widespread movement of cultured tilapia in Africa has resulted in so much interbreeding with wild species or strains that natural populations are now extremely difficult, sometimes impossible, to locate.

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**Caution!**

The effects of introductions can take a long time to develop as in the case of the almost 100-year delay between the sea-lamprey (*Petromyzon marinus*) gaining access to the North American Great Lakes and the subsequent decimation of fish stocks there through predation and parasitism.

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**Management of introductions**

The adverse impacts of introductions are not limited to conspicuous predatory species: examples of non-predatory interactions include the aquatic weeds, crayfish, tilapias and carps.

Reports on the adverse effects of introductions are many. These include devastating effects on biodiversity, reductions in production from capture fisheries, aquaculture or other sectors, and significant physical disturbances of both natural and man-
made environments, resulting in serious socio-economic hardships and economic costs.

Due to the conflicting outcomes of introductions, codes of practice to assess their benefits and risks have been developed and adopted by a number of countries or regional bodies.

While there are considerable benefits from introducing aquatic species (17% of world finfish aquaculture production is from introduced species), risks are also involved. As such, a set of guidelines on eventual introduction of a species is proposed here.

Experience has shown that animals eventually escape the confines of a facility, thus, introduction of new species for aquaculture should be considered as a purposeful introduction into the wild, even if the quarantine or hatchery facility is a closed system.

Before considering the introduction of a particular species, seriously look for a local alternative first. Delay the introduction if a local species shows promise. Study what potential use the local species is intended for. This point cannot be stressed enough because, often a local species is available but it is not known to fulfill the identified purposes.

When the introduction of a species is considered, someone, an organization, private business or government agency, hereafter called the introducing entity, must be responsible for the transport of the species. To ensure that introduction of aquatic species proceeds responsibly, the following guidelines are proposed, based on the ICES/EIFAC codes of practice, which have been adopted in principle by FAO regional fishery bodies.

The introducing entity should develop a proposal, which includes:

- Planned use of the species, planned benefits and constraints
- Location of the facility/waterbody where the species are going to be introduced and who the stakeholders are in that facility/waterbody (national or international)
- Biological information on the species
- Geographical location of the species being proposed and information on that area
- A description of similar introductions of the considered species in other areas, if available
The review panel should be independent, and not linked to the introducing entity. The formation of an external review panel, with the potential participation of foreign experts, may be considered. Another option is a panel, with the participation of those knowledgeable in local conditions and priorities. Of course a combination of the two is another possibility.

The review panel should be multidisciplinary and should include experts in:
capture fisheries, aquatic ecology, aquaculture, fish health and quarantine, human health, socio-economics, conservation, genetics, agriculture, private sector development, and rural development.

An independent review should be conducted by a panel to evaluate the proposal, the impacts and risks/benefits of the proposed introduction. The panel can look into:

- Ecological requirements/interactions and genetic concerns:
  - the potential range of establishment
  - the potential ecological consequences
  - the potential genetic consequences of the introduction
  - desirable genetic bases of stocks used, and
  - unintended or undesirable impacts on resident genetic resources

- Socio-economic concerns:
  - clearly define and quantify the intended purpose of introduction
  - clearly identify and quantify the problem the proposal aims to rectify
  - clearly identify and quantify
alternative methods of addressing the same problem
- identify and quantify the target beneficiaries
- identify and quantify the non-target people at risk
- assess the economic costs of undertaking the introduction itself

- Pathogens
  - Minimizing the spread of diseases and parasites and quarantine arrangements

The findings and advice should be communicated to the review panel, the introducing entity, and the decision-makers, after which all parties, including communities from the concerned area, will be given the opportunity to comment. The review panel comes up with its recommendation -- to accept, refine, or reject the proposal -- so that all parties understand the basis for any decision or action. Decision-makers will use the advice to make a decision.

If the introduction of a species is approved, quarantine, containment, monitoring and reporting programs have to be implemented.

**Decision maker(s)**
This can be a person or group of persons with legal authority to decide whether or not an introduction can be made.

**Education**
Countries should endeavor to publicize and improve public awareness of both the issues involved in introductions and the procedures adopted to deal with such issues.

Education should be aimed at all sectors, including fisheries and aquaculture managers and scientists in both public and private sectors, users of aquatic resources, especially business communities (who often have the most to lose from inappropriate movements yet are often the most vocal supporters of inappropriate introductions), as well as the general public. This reduces the incidence of unapproved introductions, and reduces the frustration of those

**References**


whose proposals were denied. When people understand a rational system and think it is fair, they have less cause to complain, and are less likely to ignore regulations and agreements.

For more information concerning the introduction of exotic species and the guidelines, please contact local authorities and The Asian Fisheries Society (P.O. Box 2725, Quezon City, Central Post Office, 1167 Quezon City, Philippines), the Chief of the Inland Water Resources and Aquaculture Service of the FAO (Viale delle Terme di Caracalle, 00100 Rome, Italy), or the Database on Introductions of Aquatic Species (DIAS):


Prepared by:  
Felix Marttin and Zubaida Basiao
As in crop and livestock farming, a disease outbreak is considered one of the associated risks in aquaculture. Hence, the principle "Prevention is better than cure" is strictly followed to prevent disease-associated losses. However, aquaculture systems are more complicated, as the aquatic environment, which is relatively more dynamic than the terrestrial environment, plays an important role in the disease process and in determining the type and effectiveness of treatment and other management measures.
Aquatic animal health management includes steps to fight the three causes of diseases, namely:

- pathogen
- farmed animal’s susceptibility to diseases
- environmental stress

Primary health care emphasizes the first two aspects of health management. By resorting to simple and practical measures, the risk of disease outbreak can be minimized. Treatment measures to control and cure the disease is the last resort as they are complicated, expensive and, at times, may not succeed. Success depends on quick and precise diagnosis, proper selection of therapy, accurate calculation of doses, route and method of application, etc. It also requires expertise, skill and resources that small-scale farmers might not be able to mobilize. Primary health care, on the other hand, is simple and cost-effective and must be incorporated into farming practices.

**Management of rearing environment**

Management of rearing environment is the most vital area in disease prevention and control. It helps eliminate various stress factors to maintain the proper health of farmed animals as well as strengthen their defense system against disease-causing organisms. Management of rearing environment includes the following measures:

- **Disinfection of pond**

Before initiating the farming operation, it is essential to disinfect the pond by draining and sun drying until the pond bottom cracks. If possible, the bottom should also be scraped and the upper portion of the sediment removed. As an alternative, certain disinfecting materials such as quick lime (200-500 kg/ha depending upon soil pH) or bleaching powder (25-30 kg/ha) may be applied over the freshly dewatered pond bottom and left to react for a week before refilling the pond with water. An interval of about seven to ten days between filling the unit with water and stocking should also be observed to eliminate most of the obligate pathogens (those that will not survive without finding a host) from the environment.
Commonly encountered environmental stressors

- Polluting agents (pesticides, industrial wastes, city sewerage, etc.)
- Algal toxins
- Toxic gases (ammonia, hydrogen sulphide, excessive free carbon dioxide etc.)
- Nitrite
- Abrupt changes in environmental parameters like temperature, pH, dissolved oxygen, salinity, etc.

In the case of cage culture, it is important to disinfect the cage before and after harvesting. After the crop is harvested, the cage is lifted and thoroughly washed with quick lime solution and allowed to dry in the sun for two to three days. During the culture period, the cage should be cleaned once a week by wiping out all the dirt and wastes that remain.

- **Eradication of wild fish and other aquatic animals**

Wild fish and crustaceans are potential sources of disease-causing agents. In case dewatering is not feasible, as with undrainable pond, certain safe piscicides are applied to the pond to eradicate the existing fish and other aquatic animals. Quick lime (1000-1200 kg/ha/m), bleaching powder (50-60 kg/ha/m), Mohua (Bassia latifolia) oil cake (2500 kg/ha/m), and tea seed powder (100-150 kg/ha/m) are some of the commonly used materials for this purpose. After the application of piscicides, the entry of fish and other animals into the pond should be prevented. As some fish eating birds and mollusks also serve as intermediate hosts for many parasites that infect fish and humans, care should be taken to keep the pond clear of vegetation that provide substrate for molluskan larvae. Introducing some species such as black carp or any native species of mollusk-eating fish helps prevent digenetic trematode infections to a considerable extent. Hanging wide meshed net over the pond prevents entry of birds.

- **Selection of stocking materials**

It is advisable to stock only healthy and physically vigorous seed material to ensure better survival and growth. Before accepting the seed, know the source and reputation of the production unit in maintaining health and hygiene. Check the health status of the batch on a random sampling basis to avoid the risk of introducing infected stock.

<table>
<thead>
<tr>
<th>Some tips for selecting fish seed</th>
<th>Desired</th>
<th>Undesired</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Vigorous and actively swimming</td>
<td>Lethargic, abnormal swimming behavior</td>
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<tr>
<td>-------------------------------</td>
<td>--------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Normal body color</td>
<td>Darker or abnormal color</td>
<td></td>
</tr>
<tr>
<td>Soft to touch</td>
<td>Rough to touch, excessive mucous secretion</td>
<td></td>
</tr>
<tr>
<td>No sign of any patch, spot or lesion</td>
<td>Appearance of discolored patch, spots, cysts, lesions, etc.</td>
<td></td>
</tr>
<tr>
<td>Fins - intact/complete</td>
<td>Broken fin tips</td>
<td></td>
</tr>
<tr>
<td>Gills - deep red and without any sign of hemorrhage, spots or cysts</td>
<td>Discoloration/broken gill lamellae, appearance of hemorrhagic spots, cysts, etc.</td>
<td></td>
</tr>
<tr>
<td>Quick response to external stimuli such as tapping, touching, etc.</td>
<td>No or feeble response to external stimuli</td>
<td></td>
</tr>
</tbody>
</table>

**Tips on the selection of healthy shrimp postlarvae**

- Actively swimming with straight body
- Dark color (gray, brown to black) with dark pigmentation in the tail area
- Red to pink color indicates sign of stress so the seed should be discarded.
- Normal shape of appendages and rostrum. Seeds that show black color and erosion of the appendages should be discarded.
- Quick response to external stimuli.
- Swimming against the current when the water of the container is stirred. When the current subsides, they cling to the sides to avoid being swept into the center of the container.
Selection of shrimp post larvae for stocking by conducting formalin stress test

- Take 2-3 liters of adequately aerated formalin solution (100 – 150 ppm).
- Introduce 150 randomly selected post larvae (PL) from the batch of seed to the solution and keep for 30 minutes (150 ppm solution without aeration) to two hours (100 ppm solution with aeration).
- Observe the mortality.
- Discard the seed if the mortality is more than 2%.

Separation of young from brood fish

Brood fish may serve as carrier of disease-causing organisms without exhibiting any pronounced clinical symptom. Sometimes, they survive the occurrence of epizootics due to built-up immunity and may retain some pathogens. To avoid such risk, separate the young from the brood fish.

Removal of dead fish

The virulence of pathogens often increases with passage through the host. Remove dead fish and those specimens showing pronounced symptoms of diseases.

Prevent overcrowding

Overcrowding results in waste build up, decreased availability of space, feed and oxygen, and deterioration of water quality. Follow proper recommendations on stocking density for nursery, rearing and stocking ponds.

Water quality

Abrupt and wider fluctuations in some of the environmental parameters such as dissolved oxygen, pH, carbon dioxide, turbidity, etc., cause intense stress on the farmed aquatic animals. Some of the naturally generated toxic materials like hydrogen sulfide, ammonia and dinoflagellate toxins also often exceed the tolerance limit of the farmed animals and cause serious problems. Anaerobic condition of the pond bottom sediment may result in excessive production of marshy gases like methane, ammonia, hydrogen sulfide etc. Periodical raking of pond bottom at noontime, when the dissolved oxygen level is at its peak, helps aerate pond sediment, thereby reducing the formation of toxic gases. However, bottom raking is not advisable for shrimp ponds.

Excessive application of fertilizers and the accumulation of nutrients in the bottom sediment induce the appearance of algal and bacterial blooms leading to dissolved oxygen depletion. To maintain proper health and optimum utilization of feed, the dissolved oxygen level should not drop below 3.0 mg/l in freshwater fish culture and 5 mg/l in brackishwater shrimp culture ponds. The toxicity of carbon dioxide, ammonia and hydrogen sulfide increases with the decrease in dissolved oxygen levels. Similarly, the toxicity of hydrogen sulfide increases with decreasing pH.
When pH values remain above 9 and below 6 species may survive but do not grow well. For shrimps, it is important to maintain the pH of the rearing environment between 6.5 and 8. Liming helps maintain the desired pH and also prevents daily fluctuations. Proper and timely management of soil and water by manipulating feeding, fertilization, liming, addition/exchange of water, aeration, etc., eliminate most causes of environmental stress.

- **Proper feeding**

Any reduction in quantity and quality of feed may cause deficiencies or diseases in the fish or make them susceptible to infections. It is important to follow the recommended feeding rate for specific stages of farming. Feeding is more critical during the early stages (larvae and fry) of high density rearing when the availability of natural fish food is limited. Balanced feed, with desired levels of macro and micronutrients and vitamins, should be given to prevent diseases like lardosis, scoliosis, etc. Proper feeding also helps prevent cannibalism in catfish and shrimp culture systems.

<table>
<thead>
<tr>
<th>Note</th>
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<tr>
<td>- Early morning (dawn) surfacing of fish and gasping for air indicate depletion of dissolved oxygen.</td>
</tr>
<tr>
<td>- In China, some farmers test the dissolved oxygen level by introducing some small fish known for their high oxygen demand. If the fish start surfacing soon after their release in the water being tested, the water must be deficient in oxygen.</td>
</tr>
<tr>
<td>- A moderate level of phytoplankton in both nursery and grow-out ponds must be maintained for better health of shrimp. Light green color indicates moderate level of phytoplankton.</td>
</tr>
</tbody>
</table>

- **Proper handling**

The rougher the handling, the greater is the stress and the risk of disease outbreak. Farmed aquatic animals should not be handled and transferred under hot weather conditions as high temperatures raise metabolic activity and place additional stress on the animals. In the case of fishes, care should be taken not to break the protective mucous coating of the skin.
Disinfection of net after its use in infected pond

After using the net in an infected pond, be sure to thoroughly wash and dry it before use in another pond. It is also advisable to disinfect the net using disinfectants.

Water supply and drainage

In designing a farm, be sure to provide separate water supply and drainage facilities for individual ponds to avoid the flow of water from infected ponds into the other ponds.

Disinfection of hatchery and other facilities

All hatchery jars, troughs, tanks, utensils, tools, water holding and supply systems, nets and transport facilities should be thoroughly cleaned and disinfected before and after each hatching cycle to eradicate pathogens. Disinfection, through washing/emersion, can be done by using a concentrated solution of disinfectant. Some of the effective and commonly used disinfectants are chlorine, sodium hydroxide, salt, potassium permanganate, etc. Chlorine is probably the most widely. It is easily available in liquid form as sodium hypochlorite and in powdered form as bleaching powder. Solution of 1-2% chlorine is effective against bacterial, fungal and viral pathogens. However, it is also toxic to farmed aquatic animals, thus, disinfected items should be rinsed thoroughly of chlorine residues before use.

Prophylactic measures

Application of drugs and chemicals before the onset of a disease is very effective in preventing the outbreak of diseases. This method aims to eliminate pathogens, which may be in the host or the culture facility. Several methods are employed for chemoprophylaxis. Baths, oral and injection routes of administration of drugs are most common. Again, several types of baths such as dip, shot and long bath, flush, constant flow etc. may be used depending on the need, the availability of the facilities and the farmers’ own experience.

Treatment of eggs

Fish eggs may be treated by dipping in potassium permanganate solution (50-100 ppm) for one to two minutes. Formalin is another commonly used therapeutant (250 ppm).

Treatment of fry/fingerlings

It is important to acclimatize and treat the fry/fingerlings before stocking. Discard the
water and dip the fry/fingerlings in 1-2% of common salt solution or 50 ppm of potassium permanganate for one to two minutes before releasing them into the culture facility. Stocking should always be done during cool morning or evening hours.

Treatment during sampling

It is advisable to conduct periodical sampling, at least once a month, to check the health and growth of the seed. Periodical netting should be avoided during warmer parts of the day. Before the seeds are returned to the pond, they should be bathed in 50-100 ppm of potassium permanganate solution.

Steps in pre-stocking acclimatization of seed

1. Place the plastic bag containing seed material in the water of the culture facility and allow to float for 30-60 minutes.

2. Add equal amounts of water from the facility where seed is to be stocked and keep for another 20-30 minutes.

3. Give the seeds a prophylactic treatment before releasing them into the culture facility by dipping them either in salt or potassium permanganate solution.

Treatment of broodstock
Give prophylactic treatment to shrimp/fish broodstock by bathing in 150-200 ppm of formalin for about five minutes before release. Other commonly available therapeutants like potassium permanganate (50-100 ppm) and common salt solution (2-3%) may be used as dip treatments (1-2 minutes) for fish brooders.

**Caution**

Handle formalin with care.

**Conclusion**

By following these practices, the outbreak of diseases can be avoided. As soon as there is a sign of any disease, it is better to consult a specialist for help in diagnosing the disease and for treatment and environmental measures. It is equally important to discuss the problem with neighboring farmers as an early warning. Measures can be taken individually and collectively to avert any larger catastrophe. If the disease is spreading fast and no immediate assistance is available, it is advisable, depending on size, to harvest the entire stock.

Prepared by:

Dilip Kumar  
P.P.G.S.N. Siriwardena
Small-scale aquaculture in ponds and rice fields is generally considered valuable because of its contributions to food security, income generation and better nutrition for the farmer. However, it has been argued that an expansion of aquatic environments such as ponds or rice fields may also provide additional breeding grounds for various vectors of medical importance. At the same time, based on initial field observations, there have been studies examining the potentially beneficial role and contribution of fish to the management of pests in rice. Promising as well as disappointing results have been documented. This paper summarizes important findings, assesses the important reasons for success or failure, and provides recommendations on maximizing the positive impacts of aquaculture production and development.

Fish as biocontrol agents

The most common fish species found in paddies and ponds include common carp (Cyprinus carpio), Nile tilapia (Oreochromis niloticus) and silver barb (Barbodes gonionotus). However, there are a large number of both stocked and additional wild fish species with potential for biocontrol in ponds and rice fields.

Among these are larva-feeding and mollusk-feeding fish, which are of considerable importance in the control of vectors that cause human diseases like malaria and schistosomiasis. Other species of fish appear to be effective in controlling agricultural pests, for instance, common carp which consume a lot of immature golden apple snails and therefore directly impact the population dynamics of this rice pest. Some fish eat plants and, thus, help in weed control.
The effectiveness of fish in rice fields is hard to document and there is no evidence for an optimal rate for fish stocking density in pest control. High densities are presumed to be more effective. Understanding the role of fish in the rice field ecosystem is important if they are to be used as biocontrol agents, especially if they are introduced only for that purpose.

**Selected vectors of medical importance**

**Insect vectors and related diseases**

**Malaria**

- Caused by single-celled protozoan parasite of the genus *Plasmodium*; four species infect humans
- Malaria is transmitted by the bite of the infected female mosquitoes of the genus *Anopheles*.

**Arboviral diseases**

- Transmitted by insects, e.g., *Culex* species that have previously fed on infected vertebrates (mammals or birds)
- Aquaculture allows close contact between the virus' original host, the vector, and humans.

**Selected control measures in pond and rice field aquaculture**

- Construction of steep banks
- Removal of vegetation
- Removal of small pools of water around the pond
- Maintenance of rich biodiversity
- Intermittently irrigation
- Synchronous rice planting
- Crop rotation (wet/dry)
- Proper weeding
- Biological control with fish:
  - larvivorous fish feeding on mosquito larvae; and
  - herbivorous fish feeding on vegetation.

For biological control it is important to understand the vectors' ecology. *Anopheles* species breed in stagnant water bodies and sunny partly shaded pools of water. Several *Culex* species are found in marshes, ponds and ditches. When fish are stocked which not only inhabit the same environment, but also are known to feed on these vectors, the chances of successful biocontrol are good.

**Assessment of biological control with fish**

*Gambusia affinis*, the so-called mosquito fish, is the most widely used species for this
purpose. In California rice fields, this fish is introduced each year shortly after fields have been flooded. The live-bearing Gambusia produces several broods during the summer months and an initial stocking rate of 750 fish/ha has given good results in the United States. Good results were also achieved in several other countries.

As Gambusia has no economic value, the Chinese have tried to combine mosquito control and production of food fish. This dual-purpose rice-fish farming has been successfully practiced with common carp at a stocking rate of 8250 fish/ha. Anopheline and culicine larval populations were reduced by 90% and 70%, respectively. In Indonesia, a similar approach was followed. Fingerlings of food fish were given to farmers as an incentive so they would cooperate in the use of the guppy Poecilia reticulata, which had no food value, for biocontrol purposes. Good results in mosquito vector control have been obtained in Korea using indigenous fish species.

Caution!

- Care should be taken that introduced fish do not replace indigenous fish by filling the same ecological niche.
- Not all mosquito species are equally controlled and the impact of introduced exotic fish on non-target organisms, including natural enemies of mosquitoes, may be significant.

Combinations with other control measures are recommended particularly where fish seed is hard to obtain, e.g., a combination of stocking fish and applying Bacillus thuringiensis has been successful in mosquito control in India.

Snail vectors and related diseases

Schistosomiasis

- In several Asian countries, Schistosoma japonicum is endemic.
- In Africa, two forms -- urinary schistosomiasis caused by adult worms of Schistosoma haematobium and intestinal schistosomiasis caused by Schistosoma mansoni -- are found.
- Eggs of the schistosome worms hatch when they come into contact with freshwater. Larvae infect certain species of freshwater snails (Oncomelania, Biomphalaria and Bulinus).
- After multiplication, cercariae are
The life cycle of *Schistosoma japonicum* is complex and encompasses development in two hosts and two short-lived water-borne forms. When fish feed on these intermediate host snails the life cycle of the disease is interrupted. Released from the snails, which when they come into contact with humans, penetrate the skin and migrate to abdominal blood vessels.

**Ecological requirements of the snails**

- Snails are generally aquatic, are found in shallow waters near the shore and slow-moving. They dry out when water levels fall and plant shelter is lacking.
- They are highly tolerant of temperature differences.
- *Oncomelania* snails are amphibious and prefer floodplain forests, swamps, waterlogged grasslands, stream, rice fields, irrigation canals, road ditches and borrow pits.

Wetlands around the Mekong River in Southern Laos are inhabited by many different snails species. At least one snail *Tricula aperta*, acts as the vector for the parasite *Schistosoma mekongi* which can infect humans.

**Selected control measures in pond and rice field aquaculture**

- Construction of steep banks
- Removal of vegetation
- Proper water management
- Screening of water inlets
- Pond drying
- Cleaning and lining of irrigation canals
- Biological control of snails using fish
- Use of molluscivorous fish feeding on snails and mosquito larvae
- Use of planctivorous fish feeding on snail cercariae
- Use of herbivorous fish feeding on vegetation

**Assessment of biological control of snails using fish**

Fish and crayfish may successfully control snails in ponds and reservoirs. Some fish species have specialized on snail feeding such as the black carp *Mylopharyngodon piceus* from China or various cichlids from Africa. The black carp has powerful pharyngeal teeth adapted to crushing mollusks and has been traditionally used in countries like China to control species of snails, which are nuisance organisms or intermediate hosts in parasite transmission.
Systematic studies on the performance of fish as snail eaters in water bodies are rare. After three years of observation, it was found that in rice fields in Katanga majority of snails were controlled by *Haplochromis mellandi* and *Tilapia melanopleura*, stocked at 200 fish/ha and 300 fish/ha, respectively. The snail-eating ability of *Sargochromis codringtoni*, a cichlid, was successfully tested in laboratory studies in Zimbabwe.

Good experimental results were achieved when the *Louisiana* red swamp crayfish was introduced into small rain-filled quarry pits to control the schistosome-transmitting *Biomphalaria* and *Bulinus* snails in Kenya. However, trials with another promising African cichlid, *Astatoreochromis alluaudi*, revealed that the fish were only successful at reducing snail populations if "there was nothing better to eat". Further investigations showed that the fish (from juvenile age one) need solid jaws to crush the snails but do not develop such jaws if they can find other, preferable foods.

**Selected pests of agricultural importance and their control**

**Stemborers**

There is evidence of a lower incidence of stemborer damage when fish are stocked. Some recordings include:

- In China, damage of the young rice plants (deadhearts) was reduced from 0.37 to 0.33% with the presence of common carp and damage of the mature rice plants (whiteheads) from 0.50 to 0.25%.
In the Philippines, during a period of heavy stemborer infestation (between 10 to 20% whiteheads), damage was significantly reduced from 18% in the control (no fish) to 13% and 15% with the presence of carp and tilapia, respectively.

- In Indonesia, when an outbreak of stemborer was predicted, farmers and their families went to the fields and collected the egg masses manually to control the stemborer populations. Such flexible approaches are needed for exceptional years.

Others

There are several reports documenting either reduced numbers of agricultural pests or less damage caused by pests and diseases with the presence of fish. The pests include gall midges, caseworms, brown and whitebacked plant hoppers, sheath blight, brown spot and bacterial blight. Most of the work was done in concurrent rice-fish systems. In some cases, the underlying mechanisms were described. The control effect generally was the result of direct feeding by the fish when pests came into contact with the ricefield water during one of their development stages. Golden apple snails, for example, fall into the water immediately after hatching on the rice stem, planthoppers try to escape the predatory attack of spiders by letting themselves fall into the water surface then climbing back on to the plant, and stemborer larvae disperse by floating on the water to reach uninfested rice hills.
Observations from the field on the biocontrol of snails using fish

- When common carp was stocked in Philippine rice fields, where there were large numbers of the golden snail (an introduced aquatic pest of rice in Asia) there was an observed sharp decrease in the snail population.
- When using tilapia on snails, increasing the stocking density can compensate for their poor feeding efficiency.
- Predation depends upon the size of both fish and snails, and larger snails have a higher probability to escape predation.
- C. carpio consumes the small snails so the number of big snails may increase in rice fields stocked with carp. Additional manual control measures will be needed (initially) for the big snails as these are most damaging to the rice crop.

Vector control using fish will be more effective if the following are taken into consideration

Choice of fish species

Each fish species has a distinct feeding habit, which may be useful for biocontrol purposes. Indigenous fish fauna should be screened for this purpose.

Fish density

Fish density becomes more important when the fish species are less efficient in eating and controlling a particular organism (the fish would prefer to eat organisms other than the disease-causing organisms). This is particularly true in the case of small vectors such as chironomid, mosquito and stemborer larvae or juvenile snails. However, high stocking densities affect fish growth and harvesting small fish may discourage farmers. This practice is therefore suggested for areas where ponds and rice fields are used as fish
nurseries and fish grow-out operations demand a regular fingerling supply.

**Fish size**

Size is important when vector can outgrow predation. It is suggested to stock bigger fish in areas where golden snails are a problem.

Farmers cannot be expected to stock fish in ponds or rice fields for public health reasons only. A promising concept is to use fish, which can later be harvested for food. Nile tilapia and common carp have been introduced and established for food fish farming in many countries. Where social acceptance favors tilapia, polyculture is suggested.

**Conclusion**

Well-maintained aquaculture operations do not increase but rather contribute, often significantly, to the control of insects and snails of agricultural and medical importance.

Vector populations can exhibit changes in life history. Traits may change in response to predation. Therefore, the complete elimination of a target organism by fish cannot be expected. Biological control should not aim at the eradication or elimination of an organism. Rather, integrated vector control and integrated pest management programs should be pursued where vector populations are managed so they do not cause significant problems.

Prepared by:
Matthias Halwart
Possible Public Health Hazards Associated with Farmed Fish and Shellfish

Aquaculture system is a confined system. In spite of the best environmental monitoring and control measures, several types of contamination are likely to take place in farmed fish and shellfish.

**Importance of aquaculture**

Most of the developing countries contributing significantly to aquaculture production are situated in the tropics and subtropics and most of the information available on the hazards and public health aspects of fish and fishery products concentrate mostly on the marine fish and fish products of tropical waters. Information on hazards associated with aquaculture products from warm waters is sparse.

**Microbes and parasites**

Food-borne diseases mostly come from consumption of fish infected by pathogenic bacteria, viruses or parasites. However, these become significant only when raw or inadequately cooked fish is consumed. Trematode parasites that can cause illness ranging from debilitation to cancer or even death are the most important. Infection caused by such parasites is found in geographical areas where they are endemic in the natural fish population.
Infection by food-borne trematodes
- Infection by pathogenic bacteria, viruses or parasites
- Contamination by agro-chemicals used for pest control
- Contamination by residues of growth promoters, antibiotics, veterinary drugs, etc.
- Contamination by heavy metal residues

Bacterial contamination, especially by the pathogenic species, is a potential hazard in aquaculture systems. The level of contamination of farmed fish and shellfish will depend greatly on the bacterial quality of the water body as well as the environment. Proximity to human habitations can result in increased levels of contamination by several pathogenic bacteria as well as fecal indicator organisms. Contamination by the bacterial population naturally present in the environment such as Aeromonas hydrophila, Clostridium botulinum, Vibrio cholerae etc. is also common. Bacterial flora such as Salmonella sp., E.coli, Entrobacterieae, Shigjella also show up because of contamination by human waste/animal excreta. The latter species can get introduced into an aquaculture system, even through birds or animals.

**Bivalves as pollution indicators**

Molluscan bivalves such as clams, mussels and oysters are considered indicators of environmental pollution by bacteria and heavy metals. They are filter feeders and accumulate such contaminants in their internal organs. Hence, they present a potential threat to the health of the consumers much more than crustaceans or finfish. The level of these pollutants in bivalves available from an area can give a clearer idea about the extent of pollution. Paralytic shellfish poisoning (PSP), diarrheic shellfish poisoning (DSP) and amnesic shellfish poisoning (ASP) are also risks associated with molluscan bivalves, whether from cultured or wild source.

**Pest control chemicals**

The pest control measures in culture systems employ chemicals to treat the fish as well as control diseases and pests. The residues of such chemo-therapeutants, if employed indiscriminately, can become a potential source of danger to consumer’s safety.
Antibiotic residues

Another threat to consumers comes from the residues of antibiotics used to control fish diseases and residues of growth promoters used in the feed. Many organisms may become resistant to antibiotics. Humans infected by such antibiotic-resistant organisms find treatment complicated.

<table>
<thead>
<tr>
<th>Hazards associated with culture system</th>
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<tbody>
<tr>
<td>■ Infection by food-borne trematodes</td>
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Toxic chemicals from industrial effluents

Another problem in cultured products is the contamination caused by industrial pollutants and agro-chemicals. Heavy metal type industrial pollutants are not considered a very significant risk in aquaculture but contamination by polychlorinated hydrocarbons and similar highly chlorinated industrial chemicals poses a real threat to cultured products.
As with any other human activity, hazards and risks which may adversely affect human health, are inherent in aquaculture production. Cultured fish and shellfish should therefore be handled and processed carefully.

Prepared by:
K. Devadasan and K. Gopakumar
Improved Handling and Quality Assurance of Fish and Fishery Products

Handling of harvested fish

Proper pre-process handling is very important to ensure quality. Fish must be handled properly because it is a highly perishable food susceptible to contamination by pathogenic bacteria. Depending on the species, there are various enzyme systems, which can play a vital role in causing spoilage. An understanding of the activity of the bacteria and enzymes is essential to retard spoilage.
Shrimp

Shrimp are important species for culture, as they give good returns to the farmers. Shrimp harvested from the wild come from unknown stock. Likewise, wild sources may contain a mix of species with different sizes and stages of growth. Farmed shrimp, on the other hand, often belong to the same species, can be reared to desired level of growth and can be harvested according to a predetermined schedule. The delay between harvesting and processing may cause the loss of some intrinsic qualities of the shrimp. Cultured shrimp is often packaged individually in quick frozen (IQF) form that gives more returns and value to the shrimp as a product.

Microbiological quality

Around 30% of the frozen shrimp processed out of traditionally farmed species contained salmonella and other pathogens, whereas similar incidences were observed in only 10% of the samples processed out of their marine counterparts. It was also observed that among the cultured species, the bacterial load was higher in the traditionally farmed shrimp than those cultured in intensive systems even though the former had low stock density and no supplementary feeding, pond fertilization, and aeration. The bacterial load of shrimp farmed in the intensive systems was lower because of the scientific approach to pond management.

It is recommended to keep the shrimp in ice-cold water containing 5 ppm chlorine (allowing a contact time of five minutes before packaging and transport) immediately after harvest to improve its quality.
Soft shell

Shrimp generally molt at night when food, temperature and light conditions are satisfactory. Shrimp shell generally contains protein, calcium compounds, particularly calcium carbonate, chitin and fat. Prior to molting, considerable amounts of protein and chitin as well as negligible amounts of calcium carbonate are withdrawn from the shell as new shell forms underneath. The entire shell is replaced and the new shell is almost hard after five hours. If the shrimp is harvested without allowing enough time for the hard shell to form after molting, the crop may contain several soft-shelled specimens.

The high calcium content and the thinness of the shell make the shrimp vulnerable to damage by acidic components (ascorbic acid, sodium bisulphate) as well as physical damage. Soft-shelled shrimp may also harbor a higher bacterial load.

Handling and transport

Farmed shrimp is very delicate and is best suited for processing as whole IQF products. Therefore, the handling practices should ensure that no damage occurs. Increased bulk density and height of package may result in loosening the head and damaging the shell. Such incidents will worsen if crushed ice is used. Higher packing density is also known to cause white patches in cultured shrimp processed in frozen whole, cooked whole or headless styles. A pack height not exceeding 30-35 cm is recommended and flaked ice should be used instead of crushed ice. The shrimp should be covered with sufficient quantity of ice so that the melted water forms a film over the shrimp and prevents oxygen from coming in contact with the material. The surfaces on which the shrimp is placed and the hands of workers handling the shrimp should be clean.
Shrimp should be transported in refrigerated/insulated vehicles. If facilities for chilling are not available, sufficient quantity of ice should be ensured. If the location of the processing plant is far from the culture area, facilities for augmenting ice supplies should be arranged en route. Sturdy containers should be employed to avoid damage during transport.

Blackening and prevention

Blackening, though not a serious problem in farmed shrimp, may take place if the shrimp is held for longer periods without ice and if the duration of transport under ice is unduly long. As a precautionary measure, ice should be applied (preferably flaked ice) after harvest and/or the shrimp should be dipped in 0.4% sodium metabisulphite solution (for a contact period of 30 seconds).

Processing and storage

Freezing

An important method of cultured shrimp preservation is by individually quick freezing in whole/headless or cooked form. Other value-added products such as battered and breaded shrimp can also be processed out of farmed shrimp. Frozen materials other than battered and breaded types are given a protective glaze coating and appropriately packaged and stored at -20°C or below.

Canning

Cultured shrimp, when canned, generally yield a very soft product. Treatment with chemicals, partial drying or mild smoking after blanching is found effective in
ensuring a soft and firm texture.

Live transport

Important species of finfish that are transported live are the carps, salmonids and tilapias. Catfishes are also transported live in Thailand. The market for live fish is increasing, perhaps influenced by cultural preferences and growing affluence. At present, such markets are becoming predominant in countries like Singapore, Malaysia, and China. Expansion into other places is indicated. Therefore, transportation of fish in live form is emerging as an important method of post-harvest handling. The transport requirements may vary with individual types of fish depending on whether they are of marine or fresh water origin. Transportation generally employs the tank method, which is suitable for bulk transport of live fish. The method involves shipping live fish in boats or tankers. Tanks are often equipped with circulation and aeration systems. The circulated water is aerated before feeding it back to the tank. Water can hold more oxygen at lower temperatures. Fish, however, require more oxygen at higher temperatures. A tank of a given volume can, therefore, hold more fish at lower temperatures than it can at higher temperatures. Therefore, the temperature of water in transport tanks is always kept low, but at levels the fish species concerned can tolerate. Fish with empty guts transport better.

However, in the case of high value products like shrimp, transport in polythene bags containing water and oxygen is increasingly practiced, particularly in transport by air. Finfishes are more prone to enzymatic problems. But it depends on species because the nature of enzymes varies from fish to fish. Maintaining low temperature helps to reduce bacterial as well as enzymatic action. Exclusion of oxygen by keeping the fish in chilled water reduces fat oxidation problems also.

Freezing preservation

Most of the cultured species of fish are suitable for freeze preservation. Air blast or spiral type freezers are the most suitable type for these fish. It is better to process them as IQF, chunks or fillets. It is advisable that the fish, (whether whole, chunk or fillet) are glazed and individually wrapped in polythene paper before cold storage.

The fish fillet can also be processed into value-added battered and breaded
products. However, fillet are skinned and treated with a dilute solution of sodium chloride before battering so that the color, flavor and taste are improved.

Some types of fish like carp have bones in the flesh, which adversely affect eating quality. Even though fillets of good size and shape can be made out of them, they cannot be processed as battered and breaded products. Processing fish mince by getting rid of the bones, using bone separators, is a better way of utilizing such fish. The mince prepared from cultured fresh water fish such as catla (Catla catla) and rohu (Labeo rohita) has been successfully used in preparing value-added products like battered and breaded fish fingers, burgers, cutlets, that are now popular items in the fastfood trade. Likewise, other low value fishes have been used in producing sausages and paste products although farmed fish are not used much for these purposes.

Canning preservation

When canned, the meat of farmed fresh water fish like rohu becomes very soft. In order to enhance texture, treating the fish fillet with 15% brine containing 0.25% calcium chloride prior to canning is found useful.

Bivalves

Bivalves are known to accumulate pathogenic bacteria and heavy metals in their internal organs due to their filter feeding habit. Being filter feeders, their stomach at any time may contain gritty materials like sand. Therefore, it is a pre-requisite that these animals are biologically cleansed before they are processed or consumed. One of the best and easiest methods of biological cleansing is to depurate them by starving in clean water from their natural habitat. By doing so, the grittiness can be brought down to non-detectable levels and the bacterial quality improved by freeing them of all pathogenic bacteria.

Whole mussel as well as meat shucked from fresh mussel yielded the best products. However, whole mussel stored under ice for two days also yields meat suitable for canning. Other preservation processes applicable for mussel meat are smoke curing, drying and marinating. Washing the meat of cultured edible oyster in 5% brine containing 0.1% acetic acid is considered a necessary pre-treatment to avoid formation of lumps and to yield meat with soft and firm texture. Processing clam meat in pickled form has been found to be economically viable. The pickle can be made to suit the taste of the intended market.
Quality assurance

Aquaculture is an important sector that contributes substantially to fish production. Though majority of the produce is consumed domestically by the producing nations, there is a significant increase in their processing for export. Because of the inherent health hazards and the regulatory requirements of the importing countries, strict observation of quality measures becomes important in the production, harvesting, handling and processing of these fishery products, whether it is for internal consumption or export.

HACCP is a quality assurance concept established by the quality conscious affluent importing nations of the West. The possible hazards that can cause quality problems, and their control points in the chain of processing operations are identified and listed first. The critical control points are then identified to ensure the quality of the finished product. Constant monitoring and documentation of identified parameters and strict management of the critical control points will ensure quality of the finished product. The earlier "quality control" concept, which involves inspection and acceptance or rejection of the end product, has given way to "quality assurance", ensuring maintenance of quality at every stage from harvesting to handling, transportation, packaging and marketing. Hygienic handling, use of high quality water for processing, etc are all part of this concept. The system is already revolutionizing fish processing, which is at last beginning to be treated as a high-tech industry dealing with a perishable food item.

The hazard analysis critical control point (HACCP) approach has to be applied for cultured products, from culture to consumption, to avoid risks associated with consumption of such fish and shellfish. Most of the hazards associated with fish processing have been detailed above. However, systems may have to be developed separately for the culture and handling of each fish and shellfish because the environment and habitat of the species under culture are different.

Development and application of HACCP based quality assurance program in the culture may not be very difficult in commercial large-scale operations. However, there are a vast number of small holdings under aquaculture, which mainly aim at distribution of the fish for domestic consumption. Operational limitations of such small systems of aquaculture may impede the development and adoption of proper HACCP based quality assurance programs.

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